Comsolout r s30a

Report date	Dec 4, 2021 7:38:50 PM

Contents

1 Global Definitions

Date	Feb 15, 2021 11:43:55 AM

GLOBAL SETTINGS

Name	Comsolout r s30a.mph
Path	E:\CFD Jens Budde\Cluster\3Blatt\comsolout_r_s30a.mph
Version	COMSOL Multiphysics 5.5 (Build: 359)
Unit system	SI

USED PRODUCTS

COMSOL Multiphysics
CAD Import Module
CFD Module

1.1 PARAMETERS

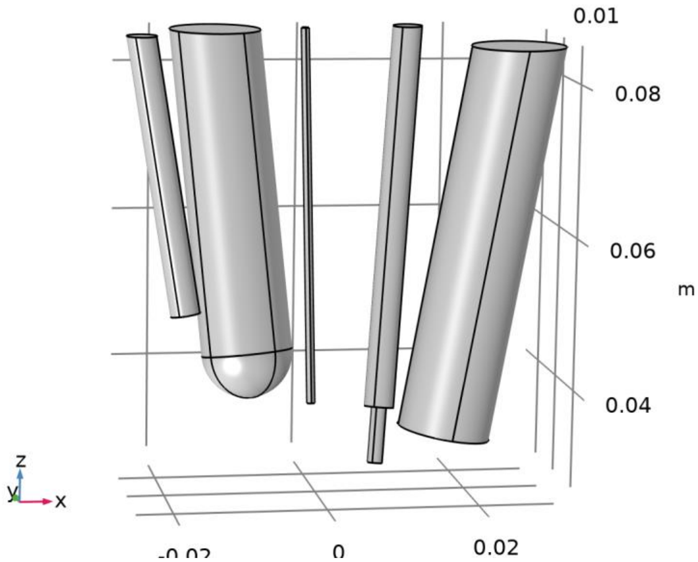
PARAMETERS 1

Name	Expression	Value	Description
D_u	3.5[cm]	0.035 m	unterer Kesseldurchmesser
H	8.5[cm]	0.085 m	Füllhöhe
r_R	1.4[cm]	0.014 m	Rührblattradius
H_ausb	0.7[cm]	0.007 m	Kesselausbuchtungshöhe
R_ab	1[mm]	0.001 m	Abrundungsradius Kessel
z_pO2	3.5[cm]	0.035 m	Position (z) der pO2-Sonde
x_pO2	1.5[cm]	0.015 m	Position (x) der pO2-Sonde
d_pO2	1.2 [cm]	0.012 m	Durchmesser pO2-Sonde
z_Beg	1.5[cm]	0.015 m	Position (z) des Begasungsrings
d_Beg	0.4[cm]	0.004 m	Durchmesser Begasungsring
d_Ring	2.8[cm]	0.028 m	Innendurchmesser Begasungsring
w_S	10.06	10.06	Sondenneigung
d_S1	0.1[cm]	0.001 m	Durchmesser der Steigrohre
slot_pO2	0	0	Belegungsplatz der pO2-Sonde
slot_S1	5	5	Belegungsplatz Steigrohr 1
slot_T	7	7	Belegungsplatz der Temperatursonde
slot_pH	8	8	Belegungsplatz der pH-Sonde
slot_S2	9	9	Belegungsplatz Steigrohr 2
slot_Beg	10	10	Belegungsplatz Begasungsring
slot_S3	11	11	Belegungsplatz Steigrohr 3

Name	Expression	Value	Description
z_pH	3.7[cm]	0.037 m	Position (z) der pH-Sonde
x_pH	1.6[cm]	0.016 m	Position (x) der pH-Sonde
z_T	4.9[cm]	0.049 m	Position (z) der Temperatursonde
x_T	2.0 [cm]	0.02 m	Position (x) der Temperatursonde
z_S1	0.2[cm]	0.002 m	Position (z) Steigrohr 1
x_S1	1.7[cm]	0.017 m	Position (x) Steigrohr 1
z_S2	3.6[cm]	0.036 m	Position (z) Steigrohr 2
x_S2	1.4[cm]	0.014 m	Position (x) Steigrohr 2
z_S3	10.4[cm]	0.104 m	Position (z) Steigrohr 3
x_S3	3.1[cm]	0.031 m	Position (x) Steigrohr 3
d_pH	1.2[cm]	0.012 m	Durchmesser pH-Sonde
d_T	0.4[cm]	0.004 m	Durchmesser Temperatursonde
pos_R	2.5[cm]	0.025 m	Rührerposition
d_Z	0.5[cm]	0.005 m	Schaftzylinderdurchmesser
h_Z	0.5[cm]	0.005 m	Schaftzylinderhöhe
h_K	0.15[cm]	0.0015 m	Schaftkegelhöhe
d_S	0.8[cm]	0.008 m	Schaftdurchmesser
l_S	H - (h_K + h_Z/2 + pos_R)	0.056 m	Schaftlänge
f	100 [rpm]	1.6667 1/s	
TIME	0[s]	0 s	
s_R	1[mm]	0.001 m	Rührblattstärke
w_R	30	30	Rührblattwinkel
h_E	0.65[cm]	0.0065 m	Ellipsoidhöhe (Halbachse)
b_E	0.65[cm]	0.0065 m	Ellipsoidbreite
r_ab	1[mm]	0.001 m	Abrundungsradius
h_Z_1	0.55[cm]	0.0055 m	Schaftzylinderhöhe
mf1	1E-4 [m]	1E−4 m	
mf2	1E-5 [m]	1E−5 m	

1.2 GEOMETRY PARTS

1.2.1 Sonden



Sonden

UNITS

Length unit	m
Angular unit	deg

GEOMETRY STATISTICS

Description	Value
Space dimension	3

Zylinder 1 (cyl1)

POSITION

Description	Value
Position	{0, 0, 0}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	d_pO2/2
Height	H

Drehen 1 (rot1)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	y - axis
Angle	10.06

Verschieben 1 (mov1)

SETTINGS

Description	Value
x	0.015
y	0
z	0.035

Drehen 4 (rot2)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	z - axis
Angle	0

Zylinder 2 (cyl2)

POSITION

Description	Value
Position	{0, 0, H}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	1.3*H
Height	1.3*H

Zylinder 3 (cyl3)

POSITION

Description	Value
Position	{0, 0, 0}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	d_S1/2
Height	H

Drehen 2 (rot3)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	y - axis
Angle	10.06

Verschieben 2 (mov2)

SETTINGS

Description	Value
x	0.017
y	0
z	0.002

Drehen 3 (rot4)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	z - axis
Angle	-150

Zylinder 4 (cyl4)

POSITION

Description	Value
Position	{0, 0, 0}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	d_T/2
Height	H

Drehen 5 (rot5)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	y - axis
Angle	10.06

Verschieben 3 (mov3)

SETTINGS

Description	Value
x	0.02
y	0
z	0.049

Drehen 6 (rot6)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	z - axis
Angle	-210

Kugel 1 (sph1)

POSITION

Description	Value
Position	{0, 0, d_pH/2}

AXIS

Description	Value
Axis type	z - axis

SIZE

Description	Value
Radius	d_pH/2

Zylinder 5 (cyl5)

POSITION

Description	Value
Position	{0, 0, d_pH/2}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	d_pH/2
Height	H

Vereinigung 1 (uni1)

COMPOSE

Description	Value
Keep interior boundaries	Off

Drehen 7 (rot7)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	y - axis
Angle	10.06

Verschieben 4 (mov4)

SETTINGS

Description	Value
x	0.016
y	0
z	0.037000000000000005

Drehen 8 (rot8)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	z - axis
Angle	-240

Zylinder 6 (cyl6)

POSITION

Description	Value
Position	{0, 0, 0}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	d_S1/2
Height	H

Drehen 9 (rot9)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	y - axis
Angle	10.06

Verschieben 5 (mov5)

SETTINGS

Description	Value
x	0.013999999999999999
y	0
z	0.036000000000000004

Drehen 10 (rot10)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	z - axis
Angle	-270

Zylinder 7 (cyl7)

POSITION

Description	Value
Position	{0, 0, 0}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	d_S1/2
Height	H

Drehen 11 (rot11)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	y - axis
Angle	10.06

Verschieben 6 (mov6)

SETTINGS

Description	Value
x	0.031000000000000003
y	0
z	0.10400000000000001

Drehen 12 (rot12)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	z - axis
Angle	-330

Arbeitsebene 1 (wp1)

PLANE DEFINITION

Description	Value
Plane	xz - plane

UNITE OBJECTS

Description	Value
Unite objects	On

Ebene Geometrie (sequence2D)

Kreis 1 (c1)

POSITION

Description	Value
Position	{d_Ring/2 + d_Beg/2, z_Beg}

SIZE AND SHAPE

Description	Value
Radius	d_Beg/2

Rotiert extrudieren 1 (rev1)

SETTINGS

Description	Value
Work plane	Arbeitsebene 1

REVOLUTION ANGLES

Description	Value
Angles	{0, 2*pi}
Start angle	20

REVOLUTION AXIS

Description	Value
Point on the revolution axis	{0, 0}
Direction of revolution axis	{0, 1}
Revolution axis	{{0, 0}, {0, 1}}

Begasungsrohr (cyl8)

POSITION

Description	Value
Position	{0, 0, 2[cm]}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	d_Beg/2
Height	H - 2[cm]

Cylinder 9 (cyl9)

POSITION

Description	Value
Position	{0, 0, 1.25[cm]}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	d_Beg/4
Height	0.75[cm]

Vereinigung 2 (uni2)

COMPOSE

Description	Value
Keep interior boundaries	Off

Drehen 13 (rot13)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	y - axis
Angle	10.06

Verschieben 7 (mov7)

SETTINGS

Description	Value
x	0.016
y	0
z	0.015

Kugel 2 (sph2)

POSITION

Description	Value
Position	{d_Ring/2 + d_Beg/2, 0, z_Beg}

AXIS

Description	Value
Axis type	z - axis

SIZE

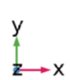
Description	Value
Radius	d_Beg/2

Drehen 14 (rot14)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	z - axis
Angle	-300

1.2.2 Reaktorkessel



Reaktorkessel

UNITS

Length unit	m
Angular unit	deg

GEOMETRY STATISTICS

Description	Value
Space dimension	3

Arbeitsebene 1 (wp1)

PLANE DEFINITION

Description	Value
Plane	xz - plane

UNITE OBJECTS

Description	Value
Unite objects	On

Ebene Geometrie (sequence2D)

Bézier Polygon 1 (b1)

POLYGON SEGMENTS

Description	Value
Control points	{{-D_u/2, 0, 0, -(3.5[cm] + 0.355*H)/2, -D_u/2}, {0, 0, H, H, 0}}
Degree	{1, 1, 1, 1}
Weights	{1, 1, 1, 1, 1, 1, 1, 1}
Type	Solid

Bézier Polygon 5 (b5)

POLYGON SEGMENTS

Description	Value
Control points	{{-0.0125, -0.008, -0.006, -0.003, 0, 0, 0, 0, -0.0125, -0.0125}, {0, 0.001, 0.004, 0.007, 0.007, 0.007, 0, 0, 0, 0}}
Degree	{2, 2, 2, 2, 1}
Weights	{1, 0.7071067811865475, 1, 1, 0.7071067811865475, 1, 1, 0.7071067811865475, 1, 1, 0.7071067811865475, 1, 1, 1}
Type	Solid

Abrundung 1 (fil1)

SETTINGS

Description	Value
Radius	R_ab

Rotiert extrudieren 1 (rev1)

SETTINGS

Description	Value
Work plane	[Arbeitsebene 1](#)

REVOLUTION ANGLES

Description	Value

Description	Value
Angles	{0, 2*pi}
Type of specification	Full revolution
Keep original faces	Off

REVOLUTION AXIS

Description	Value
Point on the revolution axis	{0, 0}
Direction of revolution axis	{0, 1}
Revolution axis	{{0, 0}, {0, 1}}

Zylinder 1 (cyl1)

POSITION

Description	Value
Position	{0, 0, H_ausb}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	1.1*r_R
Height	H - H_ausb

Arbeitsebene 2 (wp2)

PLANE DEFINITION

Description	Value
Plane	xz - plane

UNITE OBJECTS

Description	Value
Unite objects	On

Ebene Geometrie (sequence2D)

Polygon 1 (pol1)

OBJECT TYPE

Description	Value
Type	Solid

COORDINATES

Description	Value
Data source	Table

COORDINATES

xw (m)	yw (m)
0	1.3*H_ausb
1.15*r_R	1.3*H_ausb
1.15*r_R	0.88*z_pO2
x_pO2-1.05*d_pO2/2	1*z_pO2
x_pO2-1.05*d_pO2/2	H
0	H

Abrundung 1 (fil1)

SETTINGS

Description	Value
Radius	0.005

Rotiert extrudieren 2 (rev2)

SETTINGS

Description	Value
Work plane	Arbeitsebene 2

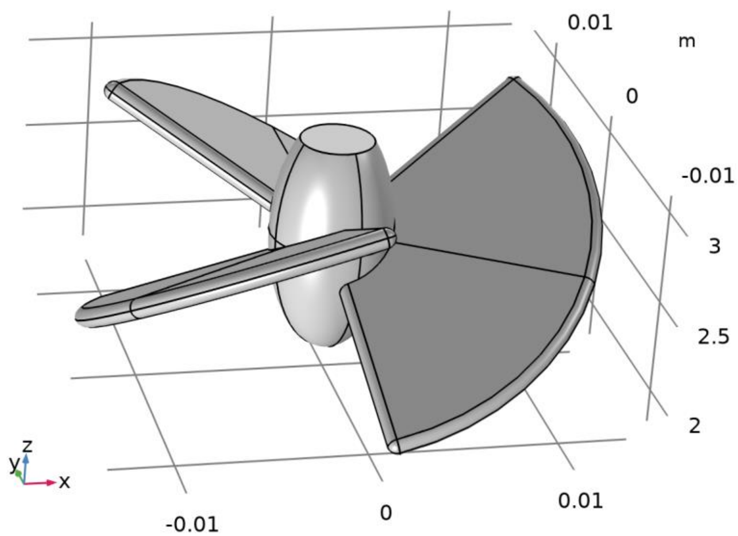
REVOLUTION ANGLES

Description	Value
Angles	{0, 2*pi}
Type of specification	Full revolution
Keep original faces	Off

REVOLUTION AXIS

Description	Value
Point on the revolution axis	{0, 0}
Direction of revolution axis	{0, 1}
Revolution axis	{{0, 0}, {0, 1}}

1.2.3 Rührer



Rührer

UNITS

Length unit	m
Angular unit	deg

GEOMETRY STATISTICS

Description	Value
Space dimension	3

Arbeitsebene 1 (wp1)

UNITE OBJECTS

Description	Value
Unite objects	On

Ebene Geometrie (sequence2D)

Kreis 1 (c1)

POSITION

Description	Value
Position	{0, 0}

SIZE AND SHAPE

Description	Value
Radius	r_R

Rechteck 1 (r1)

POSITION

Description	Value
Position	{0, 0}

ROTATION ANGLE

Description	Value
Rotation	60

SIZE

Description	Value
Width	r_R
Height	r_R

Rechteck 2 (r2)

POSITION

Description	Value
Position	{0, 0}

ROTATION ANGLE

Description	Value
Rotation	30

SIZE

Description	Value
Width	r_R
Height	r_R

Abrundung 1 (fil1)

SETTINGS

Description	Value
Radius	r_ab

Arbeitsebene 2 (wp2)

UNITE OBJECTS

Description	Value
Unite objects	On

Ebene Geometrie (sequence2D)

Rechteck 1 (r1)

POSITION

Description	Value
Position	{0, 0}

SIZE

Description	Value
Width	s_R/2
Height	r_R

Abrundung 1 (fil1)

SETTINGS

Description	Value
Radius	s_R/2

Rotiert extrudieren 1 (rev1)

SETTINGS

Description	Value
Work plane	Arbeitsebene 2

REVOLUTION ANGLES

Description	Value
Angles	{0, 2*pi}
Start angle	-90
End angle	90

REVOLUTION AXIS

Description	Value
Point on the revolution axis	{0, 0}
Direction of revolution axis	{0, 1}
Revolution axis	{{0, 0}, {0, 1}}

Arbeitsebene 3 (wp3)

PLANE DEFINITION

Description	Value
Plane	zy - plane

UNITE OBJECTS

Description	Value

Description	Value
Unite objects	On

Ebene Geometrie (sequence2D)

Rechteck 1 (r1)

POSITION

Description	Value
Position	{pos_R - s_R/2, 0}

SIZE

Description	Value
Width	s_R
Height	r_R

Abrundung 1 (fil1)

SETTINGS

Description	Value
Radius	s_R/2

Rotiert extrudieren 2 (rev2)

SETTINGS

Description	Value
Work plane	Arbeitsebene 3

REVOLUTION ANGLES

Description	Value
Angles	{0, 2*pi}
End angle	120

REVOLUTION AXIS

Description	Value
Axis type	3D
Point on the revolution axis	{0, 0, 0}
Direction of revolution axis	{0, 0, 1}
Revolution axis	{{0, 0}, {0, 1}}

Kopieren 3 (copy3)

SETTINGS

Description	Value

Description	Value
Keep input objects	On
x	0
y	0
z	0

Drehen 4 (rot4)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, pos_R}
Axis type	y - axis
Angle	180

Drehen 5 (rot5)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	z - axis
Angle	120

Vereinigung 2 (uni2)

COMPOSE

Description	Value
Keep interior boundaries	Off

Verschieben 1 (mov1)

SETTINGS

Description	Value
x	0
y	0
z	-5.0E-4

Drehen 6 (rot6)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	z - axis
Angle	-60

Drehen 1 (rot1)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, pos_R}
Axis type	y - axis
Angle	30

Kopieren 1 (copy1)

SETTINGS

Description	Value
Keep input objects	On
x	0
y	0
z	0

Drehen 2 (rot2)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, pos_R}
Axis type	z - axis
Angle	120

Kopieren 2 (copy2)

SETTINGS

Description	Value
Keep input objects	On
x	0
y	0
z	0

Drehen 3 (rot3)

SETTINGS

Description	Value
Point on axis of rotation	{0, 0, 0}
Axis type	z - axis
Angle	240

Ellipsoid 1 (elp1)

POSITION

Description	Value
Position	{0, 0, pos_R}

ROTATION ANGLE

Description	Value
Rotation	14

AXIS

Description	Value
Axis type	z - axis

SIZE

Description	Value
a-semiaxis	b_E/2
b-semiaxis	b_E/2
c-semiaxis	h_E

Quader 1 (blk1)

POSITION

Description	Value
Position	{-b_E/2, -b_E/2, pos_R + 4/5*h_E}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Width	b_E
Depth	b_E
Height	h_E

Vereinigung 1 (uni1)

SELECTIONS OF RESULTING ENTITIES

Description	Value
Resulting objects selection	On

COMPOSE

Description	Value
Keep interior boundaries	Off

1.2.4 Rührershaft

Rührershaft

UNITS

Length unit	m
Angular unit	deg

GEOMETRY STATISTICS

Description	Value
Space dimension	3

Zylinder 1 (cyl1)

POSITION

Description	Value
Position	{0, 0, pos_R + 4/5*h_E}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	d_Z/2

Description	Value
Height	h_Z

Exzentrischer Kegel 1 (econ1)

POSITION

Description	Value
Position	{0, 0, pos_R + 4/5*h_E+h_Z}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
a-semiaxis	d_Z/2
b-semiaxis	d_Z/2
Height	h_K
Ratio	d_S/d_Z
Top displacement	{0, 0}

Zylinder 2 (cyl2)

POSITION

Description	Value
Position	{0, 0, pos_R + 4/5*h_E+h_Z + h_K}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Radius	d_S/2
Height	H - (pos_R + 4/5*h_E+h_Z + h_K)

Quader 1 (blk1)

POSITION

Description	Value
Position	{-0.005, 0.0035, pos_R + 4/5*h_E+h_Z + h_K + 0.5[cm]}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Width	0.01
Depth	0.01
Height	0.004

Quader 2 (blk2)

POSITION

Description	Value
Position	{-0.005, -0.0135, pos_R + 4/5*h_E+h_Z + h_K + 0.5[cm]}

AXIS

Description	Value
Axis type	z - axis

SIZE AND SHAPE

Description	Value
Width	0.01
Depth	0.01
Height	0.004

Vereinigung 1 (uni1)

COMPOSE

Description	Value
Keep interior boundaries	Off

2 Component 1

Date	Nov 16, 2020 9:12:43 AM

SETTINGS

Description	Value
Unit system	Same as global system
Geometry shape order	Automatic

SPATIAL FRAME COORDINATES

First	Second	Third
x	y	z

MATERIAL FRAME COORDINATES

First	Second	Third
X	Y	Z

GEOMETRY FRAME COORDINATES

First	Second	Third
Xg	Yg	Zg

MESH FRAME COORDINATES

First	Second	Third
Xm	Ym	Zm

2.1 DEFINITIONS

2.1.1 Pairs

Identity Boundary Pair 3a

Pair type	Identity pair
Pair name	ap3

SOURCE SELECTION

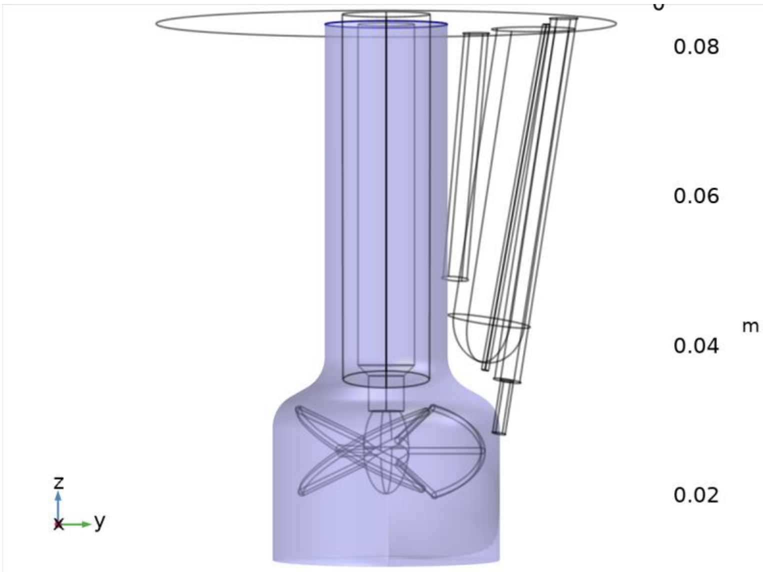
Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundary 12

DESTINATION SELECTION

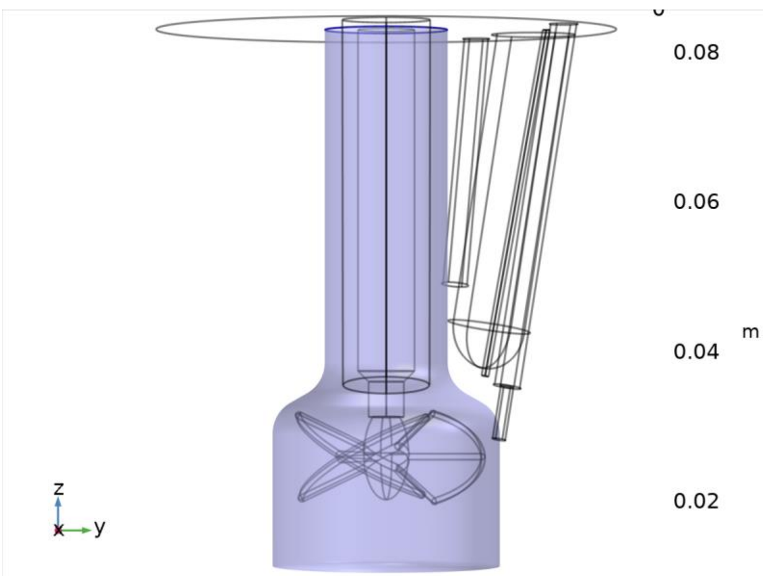
Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundary 41

SETTINGS

Name	Value
Search method	fast
Extrapolation tolerance	1e-4



Source selection



Destination selection

2.1.2 Coordinate Systems

Boundary System 1

Coordinate system type	Boundary system
Tag	sys1

COORDINATE NAMES

First	Second	Third
t1	t2	n

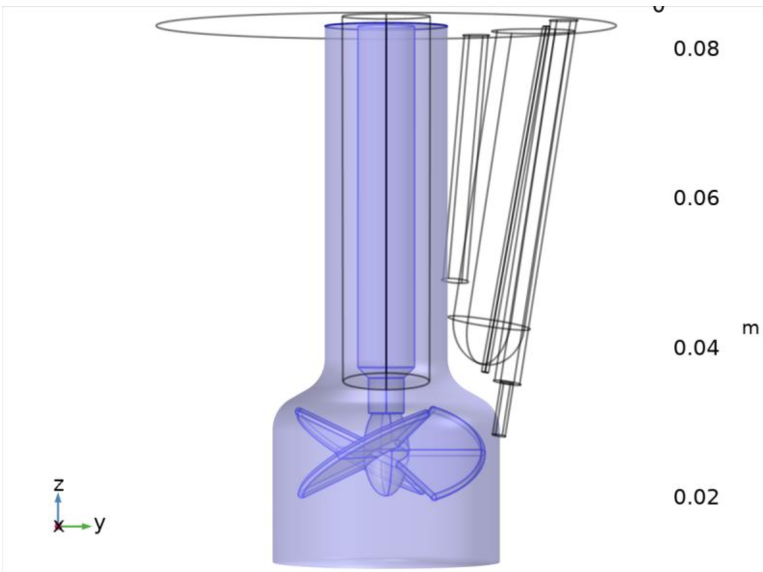
2.1.3 Moving Mesh

Rotating Domain 1

Tag	rot1

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: Domain 2



Selection

ROTATION

Description	Value
Rotation type	Specified rotational velocity
Rotational velocity expression	Constant revolutions per time
Revolutions per time	f

AXIS

Description	Value
Rotation axis base point	{0, 0, 0}

2.2 GEOMETRY 1

Geometry 1

UNITS

Length unit	m
Angular unit	deg

GEOMETRY STATISTICS

Description	Value
Space dimension	3
Number of domains	2
Number of boundaries	114
Number of edges	252
Number of vertices	155

2.2.1 Rührershaft 1 (pi8)

PART

Description	Value
Part	Rührershaft

POSITION AND ORIENTATION OF OUTPUT

Description	Value
Displacement	{0, 0, 0}
Axis type	zw - axis

SELECTION SETTINGS

Description	Value
Keep noncontributing selections	Off

2.2.2 Rührer 1 (pi7)

PART

Description	Value
Part	Rührer

POSITION AND ORIENTATION OF OUTPUT

Description	Value
Displacement	{0, 0, 0}
Axis type	zw - axis

DOMAIN SELECTIONS

Name	Keep	Physics	Contribute to
Vereinigung 1	Off	On	None

DOMAIN SELECTIONS

Name	Keep	Physics	Contribute to
Vereinigung 1	Off	On	None

DOMAIN SELECTIONS

Name	Keep	Physics	Contribute to
Vereinigung 1	Off	On	None

DOMAIN SELECTIONS

Name	Keep	Physics	Contribute to
Vereinigung 1	Off	On	None

SELECTION SETTINGS

Description	Value
Keep noncontributing selections	Off

2.2.3 Reaktorkessel 1 (pi5)

PART

Description	Value
Part	Reaktorkessel

POSITION AND ORIENTATION OF OUTPUT

Description	Value

Description	Value
Displacement	{0, 0, 0}
Axis type	zw - axis

SELECTION SETTINGS

Description	Value
Keep noncontributing selections	Off

2.2.4 Sonden 1 (pi6)

PART

Description	Value
Part	Sonden

POSITION AND ORIENTATION OF OUTPUT

Description	Value
Displacement	{0, 0, 0}
Axis type	zw - axis

SELECTION SETTINGS

Description	Value
Keep noncontributing selections	Off

2.2.5 Difference 1 (dif1)

SETTINGS

Description	Value
Keep input objects	On

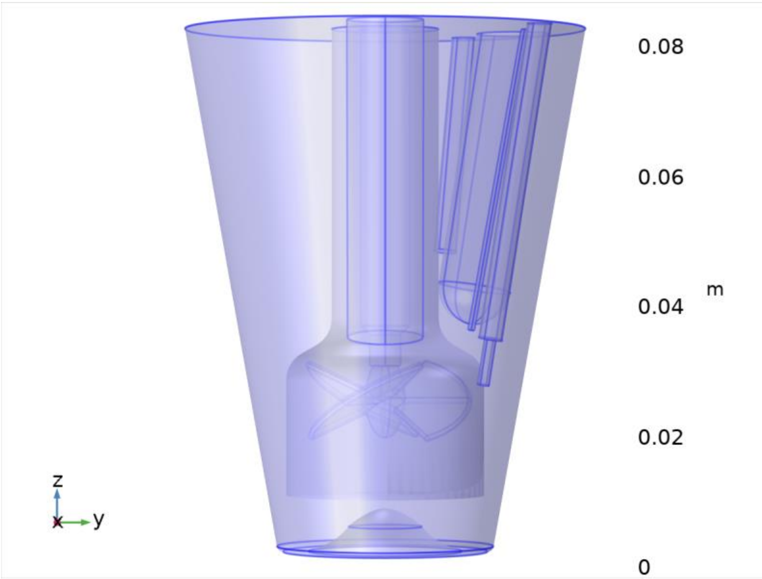
2.2.6 Form Assembly (fin)

SETTINGS

Description	Value
Action	Form an assembly

2.3 MATERIALS

2.3.1 Water



Water

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: All domains

MATERIAL PARAMETERS

Name	**Value**	**Unit**
Dynamic viscosity	eta(T)	Pa·s
Density	rho(T)	kg/m³

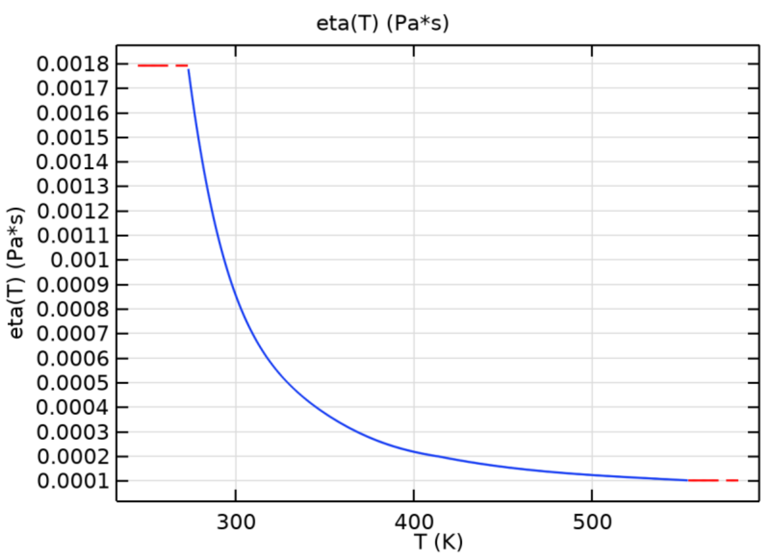
BASIC SETTINGS

Description	**Value**
Coefficient of thermal expansion	{{alpha_p(T), 0, 0}, {0, alpha_p(T), 0}, {0, 0, alpha_p(T)}}
Bulk viscosity	muB(T)
thermalexpansioncoefficient_symmetry	3
bulkviscosity_symmetry	0
Dynamic viscosity	eta(T)
dynamicviscosity_symmetry	0
Ratio of specific heats	gamma_w(T)
ratioofspecificheat_symmetry	0
Electrical conductivity	{{5.5e-6[S/m], 0, 0}, {0, 5.5e-6[S/m], 0}, {0, 0, 5.5e-6[S/m]}}

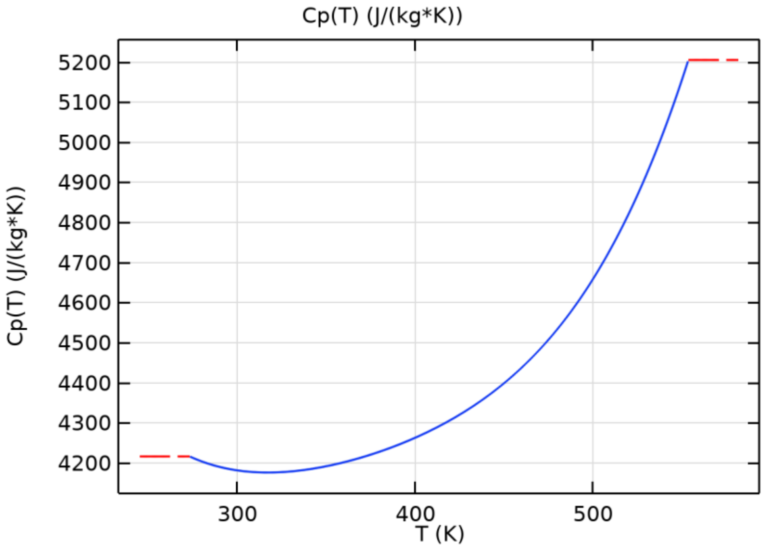
Description	Value
electricconductivity_symmetry	3
Heat capacity at constant pressure	Cp(T)
heatcapacity_symmetry	0
Density	rho(T)
density_symmetry	0
Thermal conductivity	{{k(T), 0, 0}, {0, k(T), 0}, {0, 0, k(T)}}
thermalconductivity_symmetry	3
Speed of sound	cs(T)
soundspeed_symmetry	0

FUNCTIONS

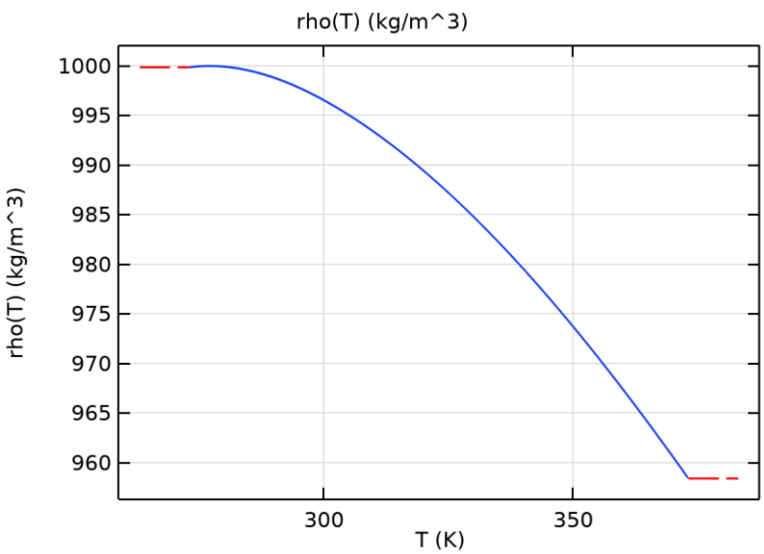
Function name	Type
eta	Piecewise
Cp	Piecewise
rho	Piecewise
k	Piecewise
cs	Interpolation
alpha_p	Analytic
gamma_w	Analytic
muB	Analytic



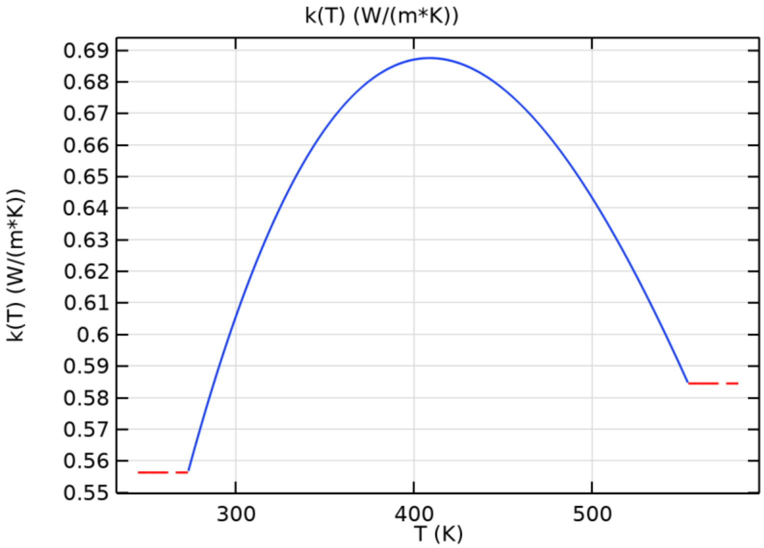
eta


Cp(T) (J/(kg*K))
5200
5100
5000
4900
4800
4700
4600
4500
4400
4300
4200
Cp(T) (J/(kg*K))
300
400
500
T (K)

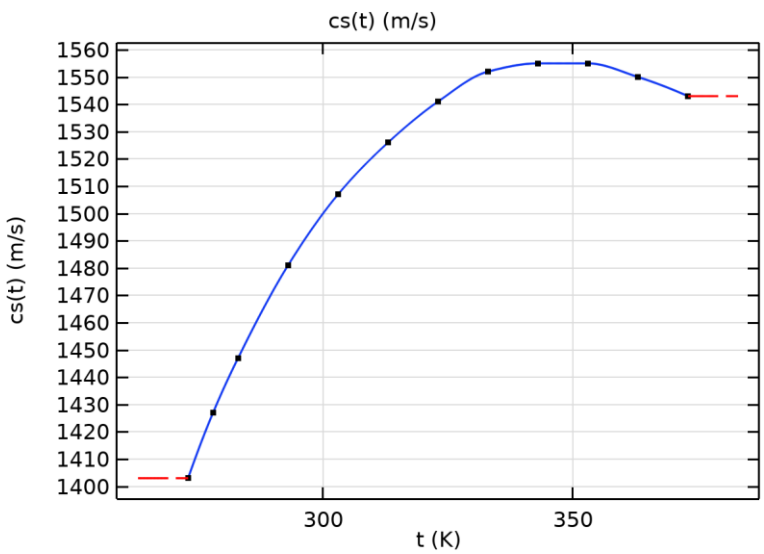
Cp


rho(T) (kg/m^3)
1000
995
990
985
980
975
970
965
960
rho(T) (kg/m^3)
300
350
T (K)

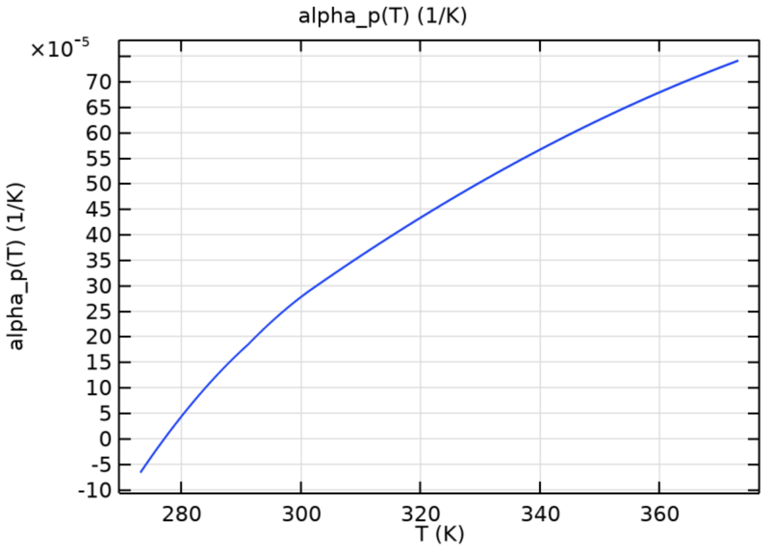
rho


k(T) (W/(m*K))
0.69
0.68
0.67
0.66
0.65
0.64
0.63
0.62
0.61
0.6
0.59
0.58
0.57
0.56
0.55
k(T) (W/(m*K))
300
400
500
T (K)

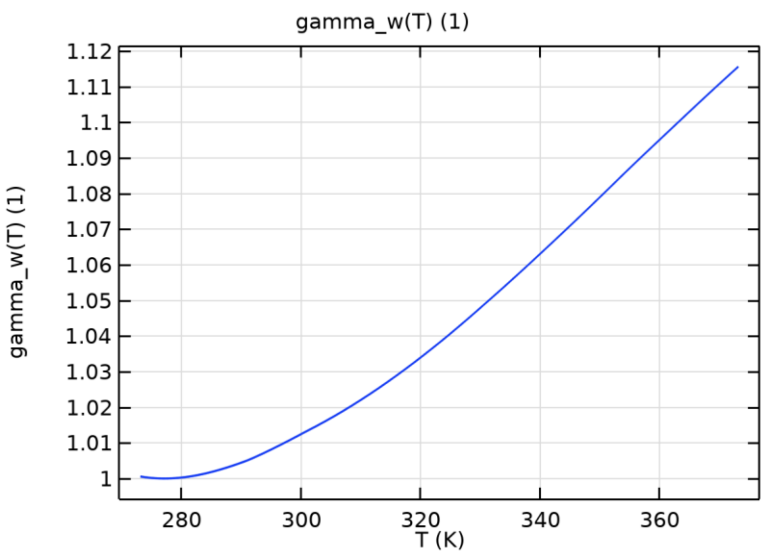
k


cs(t) (m/s)
1560
1550
1540
1530
1520
1510
1500
1490
1480
1470
1460
1450
1440
1430
1420
1410
1400
cs(t) (m/s)
300
350
t (K)

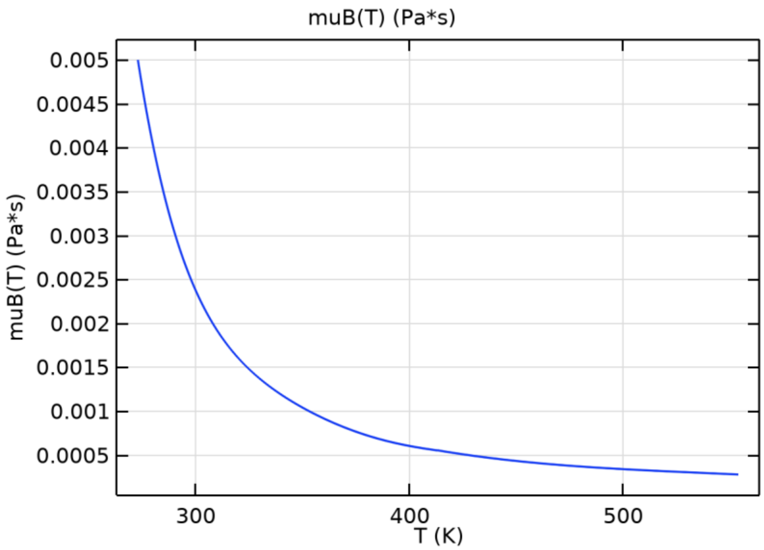
cs



alpha_p



gamma_w

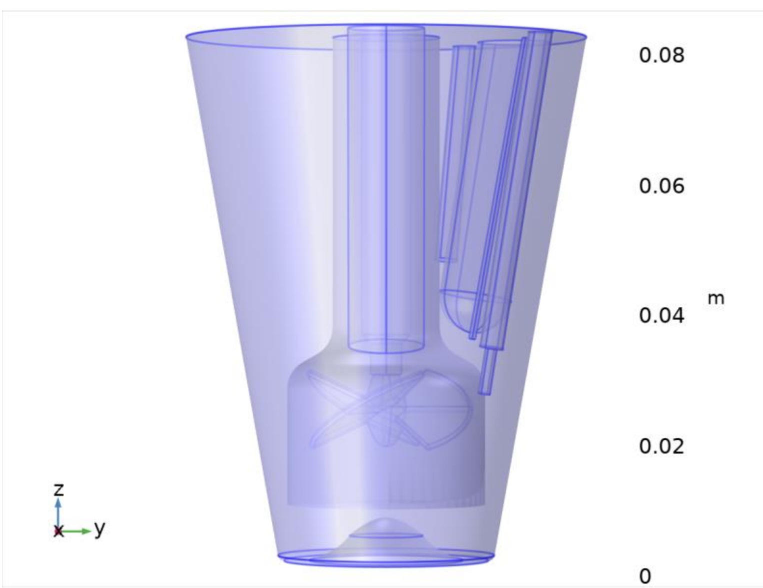


muB

2.4 TURBULENT FLOW, K-E

USED PRODUCTS

COMSOL Multiphysics
CFD Module



Turbulent Flow, k-ε

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: All domains

EQUATIONS

$$\rho(\mathbf{u}\cdot\nabla)\mathbf{u}=\nabla\cdot[-p2\mathbf{I}+\mathbf{K}]+\mathbf{F}+\rho\mathbf{g}$$
$$\rho\nabla\cdot\mathbf{u}=0$$
$$\mathbf{K}=(\mu+\mu_T)\left(\nabla\mathbf{u}+(\nabla\mathbf{u})^T\right)$$
$$\rho(\mathbf{u}\cdot\nabla)k2=\nabla\cdot\left[\left(\mu+\frac{\mu_T}{\sigma_k}\right)\nabla k2\right]+P_k-\rho\epsilon$$
$$\rho(\mathbf{u}\cdot\nabla)\epsilon=\nabla\cdot\left[\left(\mu+\frac{\mu_T}{\sigma_\epsilon}\right)\nabla\epsilon\right]+C_{\epsilon 1}\frac{\epsilon}{k2}P_k-C_{\epsilon 2}\rho\frac{\epsilon^2}{k2},\quad \epsilon=\mathrm{ep2}$$

$$\mu_T=\rho C_\mu\frac{k2^2}{\epsilon}$$
$$P_k=\mu_T\left[\nabla\mathbf{u}:\left(\nabla\mathbf{u}+(\nabla\mathbf{u})^T\right)\right]$$

2.4.1 Interface settings

Discretization

SETTINGS

Description	Value
Discretization of fluids	P1 + P1

Physical model

SETTINGS

Description	Value
Compressibility	Incompressible flow
Include gravity	On
Use reduced pressure	Off
Reference position, x component	0
Reference position, y component	0
Reference position, z component	0
Reference temperature	User defined
Reference temperature	310.15[K]
Reference pressure level	1[atm]

Turbulence

SETTINGS

Description	Value
Turbulence model type	RANS
Turbulence model	k - ε
Wall treatment	Wall functions

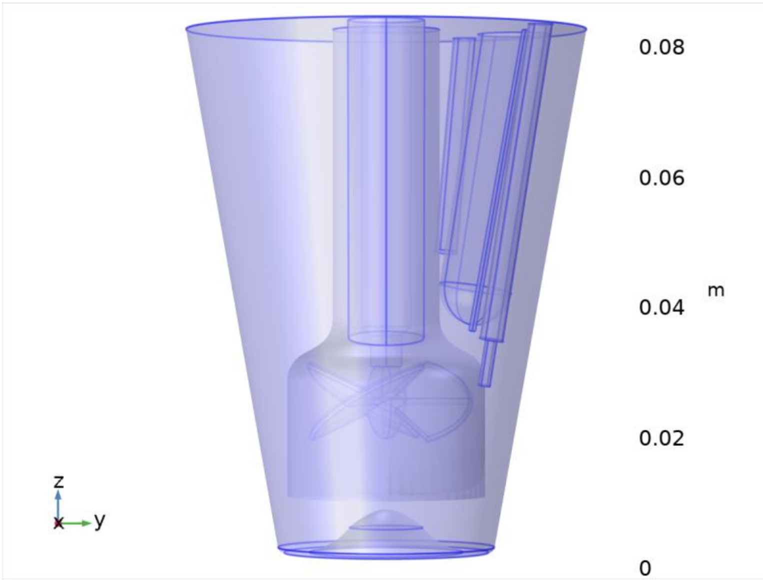
Description	Value
Edit turbulence model parameters	Off

2.4.2 Variables

Name	Expression	Unit	Description	Selection	Details
spf.Tref	model.input.Tref	K	Reference temperature	Global	Meta
spf.rrefx	0	m	Reference position, x component	Domains 1–2	
spf.rrefy	0	m	Reference position, y component	Domains 1–2	
spf.rrefz	0	m	Reference position, z component	Domains 1–2	
spf.dz	1	m	Thickness	Domains 1–2	
spf.pref	1[atm]	Pa	Reference pressure level	Domains 1–2	
spf.pA	p2+spf.pref	Pa	Absolute pressure	Domains 1–2	
spf.hasWF	0		Help variable	Boundaries 1–114	
spf.dt_CFL	1/max(spf.maxOp(sqrt(emetric_spatial(u-d(x,TIME),v-d(y,TIME),w-d(z,TIME)))),eps)	s	Time step, CFL=1	Global	
spf.sigmaw	0.2	1	Smoothing parameter	Domains 1–2	
spf.Ceps1	1.44	1	Turbulence model parameter	Domains 1–2	
spf.Ceps2	1.92	1	Turbulence model parameter	Domains 1–2	
spf.C_mu	0.09	1	Turbulence model parameter	Domains 1–2	
spf.sigmak	1	1	Turbulence model parameter	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
spf.sigmaeps	1.3	1	Turbulence model parameter	Domains 1–2	
spf.kappav	0.41	1	Turbulence model parameter	Domains 1–2	
spf.B	5.2	1	Law of the wall constant	Domains 1–2	
spf.usePseudoTimeStepping	1	1	Help variable	Global	+ operation
spf.localCFLvalue	3+if(niterCMP>=15,1.3^min(-15+niterCMP,7),0)+if(niterCMP>=40,9*1.3^min(-40+niterCMP,9),0)+if(niterCMP>=70,90*1.3^min(-70+niterCMP,9),0)		Local CFL number	Domains 1–2	
spf.locCFL	CFLCMP	1	Local CFL number	Domains 1–2	
spf.geometryLengthScale	0.016293750000000003	m	Geometry length scale	Domains 1–2	
spf.time_step_inv	max(sqrt(emetric_spatial(u-d(x,TIME),v-d(y,TIME),w-d(z,TIME))*2^gmg_level^2),spf.nu/spf.geometryLengthScale^2)	Hz	Inverse time step	Domains 1–2	
spf.tsti	nojac(spf.time_step_inv/spf.locCFL)	1/s	Help variable	Domains 1–2	
spf.nx	dnx	1	Normal vector, x component	Boundaries 1–114	
spf.ny	dny	1	Normal vector, y component	Boundaries 1–114	
spf.nz	dnz	1	Normal vector, z component	Boundaries 1–114	
spf.nxmesh	dnxmesh	1	Normal vector, x component	Boundaries 1–114	
spf.nymesh	dnymesh	1	Normal vector, y component	Boundaries 1–114	
spf.nzmesh	dnzmesh	1	Normal vector, z component	Boundaries 1–114	

2.4.3 Fluid Properties 1



Fluid Properties 1

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: All domains

EQUATIONS

$$\rho(\mathbf{u}\cdot\nabla)\mathbf{u} = \nabla\cdot[-p2\mathbf{I} + \mathbf{K}] + \mathbf{F} + \rho\mathbf{g}$$

$$\rho\nabla\cdot\mathbf{u} = 0$$

$$\mathbf{K} = (\mu + \mu_{\mathrm{T}})\left(\nabla\mathbf{u} + (\nabla\mathbf{u})^{\mathrm{T}}\right)$$

$$\rho(\mathbf{u}\cdot\nabla)k2 = \nabla\cdot\left[\left(\mu + \frac{\mu_{\mathrm{T}}}{\sigma_{\mathrm{k}}}\right)\nabla k2\right] + P_{\mathrm{k}} - \rho\epsilon$$

$$\rho(\mathbf{u}\cdot\nabla)\epsilon = \nabla\cdot\left[\left(\mu + \frac{\mu_{\mathrm{T}}}{\sigma_{\epsilon}}\right)\nabla\epsilon\right] + C_{\epsilon 1}\frac{\epsilon}{k2}P_{\mathrm{k}} - C_{\epsilon 2}\rho\frac{\epsilon^2}{k2}, \quad \epsilon = \mathrm{ep2}$$

Fluid properties

SETTINGS

Description	Value
Density	From material
Dynamic viscosity	From material

Mixing length limit

SETTINGS

Description	Value
Mixing length limit	Automatic

Model input

SETTINGS

Description	Value
Temperature	Common model input

PROPERTIES FROM MATERIAL

Property	Material	Property group
Density	Water	Basic
Dynamic viscosity	Water	Basic

Variables

Name	Expression	Unit	Description	Selection	Details
spf.geometryLeng	0.25*spf.l_mix_lim	m	Geometry length	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
thScale			scale		
spf.Fgtotx	0	N/m³	Gravity force, x component	Domains 1–2	+ operation
spf.Fgtoty	0	N/m³	Gravity force, y component	Domains 1–2	+ operation
spf.Fgtotz	0	N/m³	Gravity force, z component	Domains 1–2	+ operation
spf.k_nn	max(k2,0)	m²/s²	Regularized turbulent kinetic energy	Domains 1–2	
spf.mu	material.mu	Pa·s	Dynamic viscosity	Domains 1–2	Meta
spf.rho	subst(material.rho,spf.fp1.minput_temperature,spf.Trho,spf.fp1.minput_pressure,spf.prho)	kg/m³	Density	Domains 1–2	Meta
uxt	uxTIME-uxx*d(x,TIME)-uxy*d(y,TIME)-uxz*d(z,TIME)	1/s²	Gradient of u, x component, first time derivative	Domains 1–2	
uyt	uyTIME-uyx*d(x,TIME)-uyy*d(y,TIME)-uyz*d(z,TIME)	1/s²	Gradient of u, y component, first time derivative	Domains 1–2	
uzt	uzTIME-uzx*d(x,TIME)-uzy*d(y,TIME)-uzz*d(z,TIME)	1/s²	Gradient of u, z component, first time derivative	Domains 1–2	
uxtt	d(uxTIME-uxx*d(x,TIME)-uxy*d(y,TIME)-uxz*d(z,TIME),TIME)-d(uxTIME-uxx*d(x,TIME)-uxy*d(y,TIME)-uxz*d(z,TIME),x)*d(x,TIME)-d(uxTIME-uxx*d(x,TIME)-uxy*d(y,TIME)-uxz*d(z,TIME),y)*d(y,TIME)-d(uxTIME-uxx*d(x,TIME)-uxy*d(y,TIME)-	1/s³	Gradient of u, x component, second time derivative	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	uxz*d(z,TIME),z)*d(z, TIME)				
uytt	d(uyTIME-uyx*d(x,TIME)-uyy*d(y,TIME)-uyz*d(z,TIME),TIME)-d(uyTIME-uyx*d(x,TIME)-uyy*d(y,TIME)-uyz*d(z,TIME),x)*d(x, TIME)-d(uyTIME-uyx*d(x,TIME)-uyy*d(y,TIME)-uyz*d(z,TIME),y)*d(y, TIME)-d(uyTIME-uyx*d(x,TIME)-uyy*d(y,TIME)-uyz*d(z,TIME),z)*d(z, TIME)	$1/s^3$	Gradient of u, y component, second time derivative	Domains 1–2	
uztt	d(uzTIME-uzx*d(x,TIME)-uzy*d(y,TIME)-uzz*d(z,TIME),TIME)-d(uzTIME-uzx*d(x,TIME)-uzy*d(y,TIME)-uzz*d(z,TIME),x)*d(x, TIME)-d(uzTIME-uzx*d(x,TIME)-uzy*d(y,TIME)-uzz*d(z,TIME),y)*d(y, TIME)-d(uzTIME-uzx*d(x,TIME)-uzy*d(y,TIME)-uzz*d(z,TIME),z)*d(z, TIME)	$1/s^3$	Gradient of u, z component, second time derivative	Domains 1–2	
vxt	vxTIME-vxx*d(x,TIME)-vxy*d(y,TIME)-vxz*d(z,TIME)	$1/s^2$	Gradient of v, x component, first time derivative	Domains 1–2	
vyt	vyTIME-vyx*d(x,TIME)-vyy*d(y,TIME)-vyz*d(z,TIME)	$1/s^2$	Gradient of v, y component, first time derivative	Domains 1–2	
vzt	vzTIME-vzx*d(x,TIME)-	$1/s^2$	Gradient of v, z component, first	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	vzy*d(y,TIME)-vzz*d(z,TIME)		time derivative		
vxtt	d(vxTIME-vxx*d(x,TIME)-vxy*d(y,TIME)-vxz*d(z,TIME),TIME)-d(vxTIME-vxx*d(x,TIME)-vxy*d(y,TIME)-vxz*d(z,TIME),x)*d(x,TIME)-d(vxTIME-vxx*d(x,TIME)-vxy*d(y,TIME)-vxz*d(z,TIME),y)*d(y,TIME)-d(vxTIME-vxx*d(x,TIME)-vxy*d(y,TIME)-vxz*d(z,TIME),z)*d(z,TIME)	1/s^3	Gradient of v, x component, second time derivative	Domains 1–2	
vytt	d(vyTIME-vyx*d(x,TIME)-vyy*d(y,TIME)-vyz*d(z,TIME),TIME)-d(vyTIME-vyx*d(x,TIME)-vyy*d(y,TIME)-vyz*d(z,TIME),x)*d(x,TIME)-d(vyTIME-vyx*d(x,TIME)-vyy*d(y,TIME)-vyz*d(z,TIME),y)*d(y,TIME)-d(vyTIME-vyx*d(x,TIME)-vyy*d(y,TIME)-vyz*d(z,TIME),z)*d(z,TIME)	1/s^3	Gradient of v, y component, second time derivative	Domains 1–2	
vztt	d(vzTIME-vzx*d(x,TIME)-vzy*d(y,TIME)-vzz*d(z,TIME),TIME)-d(vzTIME-vzx*d(x,TIME)-vzy*d(y,TIME)-vzz*d(z,TIME),x)*d(x,TIME)-d(vzTIME-vzx*d(x,TIME)-vzy*d(y,TIME)-	1/s^3	Gradient of v, z component, second time derivative	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	vzz*d(z,TIME),y)*d(y,TIME)-d(vzTIME-vzx*d(x,TIME)-vzy*d(y,TIME)-vzz*d(z,TIME),z)*d(z,TIME)				
wxt	wxTIME-wxx*d(x,TIME)-wxy*d(y,TIME)-wxz*d(z,TIME)	$1/s^2$	Gradient of w, x component, first time derivative	Domains 1–2	
wyt	wyTIME-wyx*d(x,TIME)-wyy*d(y,TIME)-wyz*d(z,TIME)	$1/s^2$	Gradient of w, y component, first time derivative	Domains 1–2	
wzt	wzTIME-wzx*d(x,TIME)-wzy*d(y,TIME)-wzz*d(z,TIME)	$1/s^2$	Gradient of w, z component, first time derivative	Domains 1–2	
wxtt	d(wxTIME-wxx*d(x,TIME)-wxy*d(y,TIME)-wxz*d(z,TIME),TIME)-d(wxTIME-wxx*d(x,TIME)-wxy*d(y,TIME)-wxz*d(z,TIME),x)*d(x,TIME)-d(wxTIME-wxx*d(x,TIME)-wxy*d(y,TIME)-wxz*d(z,TIME),y)*d(y,TIME)-d(wxTIME-wxx*d(x,TIME)-wxy*d(y,TIME)-wxz*d(z,TIME),z)*d(z,TIME)	$1/s^3$	Gradient of w, x component, second time derivative	Domains 1–2	
wytt	d(wyTIME-wyx*d(x,TIME)-wyy*d(y,TIME)-wyz*d(z,TIME),TIME)-d(wyTIME-wyx*d(x,TIME)-wyy*d(y,TIME)-wyz*d(z,TIME),x)*d(x,TIME)-d(wyTIME-wyx*d(x,TIME)-wyy*d(y,TIME)-	$1/s^3$	Gradient of w, y component, second time derivative	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	wyz*d(z,TIME),y)*d(y, TIME)-d(wyTIME-wyx*d(x,TIME)-wyy*d(y,TIME)-wyz*d(z,TIME),z)*d(z, TIME)				
wztt	d(wzTIME-wzx*d(x,TIME)-wzy*d(y,TIME)-wzz*d(z,TIME),TIME)-d(wzTIME-wzx*d(x,TIME)-wzy*d(y,TIME)-wzz*d(z,TIME),x)*d(x, TIME)-d(wzTIME-wzx*d(x,TIME)-wzy*d(y,TIME)-wzz*d(z,TIME),y)*d(y, TIME)-d(wzTIME-wzx*d(x,TIME)-wzy*d(y,TIME)-wzz*d(z,TIME),z)*d(z, TIME)	1/s³	Gradient of w, z component, second time derivative	Domains 1–2	
ut	uTIME-ux*d(x,TIME)-uy*d(y,TIME)-uz*d(z,TIME)	m/s²	Velocity field, first time derivative, x component	Domains 1–2	
vt	vTIME-vx*d(x,TIME)-vy*d(y,TIME)-vz*d(z,TIME)	m/s²	Velocity field, first time derivative, y component	Domains 1–2	
wt	wTIME-wx*d(x,TIME)-wy*d(y,TIME)-wz*d(z,TIME)	m/s²	Velocity field, first time derivative, z component	Domains 1–2	
utt	d(uTIME-ux*d(x,TIME)-uy*d(y,TIME)-uz*d(z,TIME),TIME)-d(uTIME-ux*d(x,TIME)-uy*d(y,TIME)-uz*d(z,TIME),x)*d(x,TIME)-d(uTIME-ux*d(x,TIME)-uy*d(y,TIME)-	m/s³	Velocity field, second time derivative, x component	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	uz*d(z,TIME),y)*d(y,TIME)-d(uTIME-ux*d(x,TIME)-uy*d(y,TIME)-uz*d(z,TIME),z)*d(z,TIME)				
vtt	d(vTIME-vx*d(x,TIME)-vy*d(y,TIME)-vz*d(z,TIME),TIME)-d(vTIME-vx*d(x,TIME)-vy*d(y,TIME)-vz*d(z,TIME),x)*d(x,TIME)-d(vTIME-vx*d(x,TIME)-vy*d(y,TIME)-vz*d(z,TIME),y)*d(y,TIME)-d(vTIME-vx*d(x,TIME)-vy*d(y,TIME)-vz*d(z,TIME),z)*d(z,TIME)	m/s^3	Velocity field, second time derivative, y component	Domains 1–2	
wtt	d(wTIME-wx*d(x,TIME)-wy*d(y,TIME)-wz*d(z,TIME),TIME)-d(wTIME-wx*d(x,TIME)-wy*d(y,TIME)-wz*d(z,TIME),x)*d(x,TIME)-d(wTIME-wx*d(x,TIME)-wy*d(y,TIME)-wz*d(z,TIME),y)*d(y,TIME)-d(wTIME-wx*d(x,TIME)-wy*d(y,TIME)-wz*d(z,TIME),z)*d(z,TIME)	m/s^3	Velocity field, second time derivative, z component	Domains 1–2	
p2xt	p2xTIME-p2xx*d(x,TIME)-p2xy*d(y,TIME)-p2xz*d(z,TIME)	$kg/(m^2 \cdot s^3)$	Gradient of p2, x component, first time derivative	Domains 1–2	
p2yt	p2yTIME-p2yx*d(x,TIME)-	$kg/(m^2 \cdot s^3)$	Gradient of p2, y component, first	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	p2yy*d(y,TIME)-p2yz*d(z,TIME)		time derivative		
p2zt	p2zTIME-p2zx*d(x,TIME)-p2zy*d(y,TIME)-p2zz*d(z,TIME)	kg/(m²·s³)	Gradient of p2, z component, first time derivative	Domains 1–2	
p2xtt	d(p2xTIME-p2xx*d(x,TIME)-p2xy*d(y,TIME)-p2xz*d(z,TIME),TIME)-d(p2xTIME-p2xx*d(x,TIME)-p2xy*d(y,TIME)-p2xz*d(z,TIME),x)*d(x,TIME)-d(p2xTIME-p2xx*d(x,TIME)-p2xy*d(y,TIME)-p2xz*d(z,TIME),y)*d(y,TIME)-d(p2xTIME-p2xx*d(x,TIME)-p2xy*d(y,TIME)-p2xz*d(z,TIME),z)*d(z,TIME)	kg/(m²·s⁴)	Gradient of p2, x component, second time derivative	Domains 1–2	
p2ytt	d(p2yTIME-p2yx*d(x,TIME)-p2yy*d(y,TIME)-p2yz*d(z,TIME),TIME)-d(p2yTIME-p2yx*d(x,TIME)-p2yy*d(y,TIME)-p2yz*d(z,TIME),x)*d(x,TIME)-d(p2yTIME-p2yx*d(x,TIME)-p2yy*d(y,TIME)-p2yz*d(z,TIME),y)*d(y,TIME)-d(p2yTIME-p2yx*d(x,TIME)-p2yy*d(y,TIME)-p2yz*d(z,TIME),z)*d(z,TIME)	kg/(m²·s⁴)	Gradient of p2, y component, second time derivative	Domains 1–2	
p2ztt	d(p2zTIME-p2zx*d(x,TIME)-p2zy*d(y,TIME)-p2zz*d(z,TIME),TIME)-d(p2zTIME-p2zx*d(x,TIME)-	kg/(m²·s⁴)	Gradient of p2, z component, second time derivative	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	p2zy*d(y,TIME)-p2zz*d(z,TIME),x)*d(x,TIME)-d(p2zTIME-p2zx*d(x,TIME)-p2zy*d(y,TIME)-p2zz*d(z,TIME),y)*d(y,TIME)-d(p2zTIME-p2zx*d(x,TIME)-p2zy*d(y,TIME)-p2zz*d(z,TIME),z)*d(z,TIME)				
p2t	p2TIME-p2x*d(x,TIME)-p2y*d(y,TIME)-p2z*d(z,TIME)	Pa/s	Pressure, first time derivative	Domains 1–2	
p2tt	d(p2TIME-p2x*d(x,TIME)-p2y*d(y,TIME)-p2z*d(z,TIME),TIME)-d(p2TIME-p2x*d(x,TIME)-p2y*d(y,TIME)-p2z*d(z,TIME),x)*d(x,TIME)-d(p2TIME-p2x*d(x,TIME)-p2y*d(y,TIME)-p2z*d(z,TIME),y)*d(y,TIME)-d(p2TIME-p2x*d(x,TIME)-p2y*d(y,TIME)-p2z*d(z,TIME),z)*d(z,TIME)	Pa/s²	Pressure, second time derivative	Domains 1–2	
spf.Trho	spf.Tref	K	Temperature for density evaluation	Domains 1–2	
spf.prho	spf.pref	Pa	Pressure for the evaluation of density	Domains 1–2	
spf.rhoref	subst(material.rho,spf.fp1.minput_temperature,spf.Tref,spf.fp1.minput_pressure,spf.pref)	kg/m³	Reference density	Domains 1–2	Meta
spf.mumat	material.mu	Pa·s	Dynamic viscosity	Domains 1–2	Meta

Name	Expression	Unit	Description	Selection	Details
spf.srijxx	ux	1/s	Strain rate tensor, xx component	Domains 1–2	
spf.srijyx	0.5*(vx+uy)	1/s	Strain rate tensor, yx component	Domains 1–2	
spf.srijzx	0.5*(wx+uz)	1/s	Strain rate tensor, zx component	Domains 1–2	
spf.srijxy	0.5*(uy+vx)	1/s	Strain rate tensor, xy component	Domains 1–2	
spf.srijyy	vy	1/s	Strain rate tensor, yy component	Domains 1–2	
spf.srijzy	0.5*(wy+vz)	1/s	Strain rate tensor, zy component	Domains 1–2	
spf.srijxz	0.5*(uz+wx)	1/s	Strain rate tensor, xz component	Domains 1–2	
spf.srijyz	0.5*(vz+wy)	1/s	Strain rate tensor, yz component	Domains 1–2	
spf.srijzz	wz	1/s	Strain rate tensor, zz component	Domains 1–2	
spf.rrijxx	0	1/s	Rotation rate tensor, xx component	Domains 1–2	
spf.rrijyx	0.5*(vx-uy)	1/s	Rotation rate tensor, yx component	Domains 1–2	
spf.rrijzx	0.5*(wx-uz)	1/s	Rotation rate tensor, zx component	Domains 1–2	
spf.rrijxy	0.5*(uy-vx)	1/s	Rotation rate tensor, xy component	Domains 1–2	
spf.rrijyy	0	1/s	Rotation rate tensor, yy component	Domains 1–2	
spf.rrijzy	0.5*(wy-vz)	1/s	Rotation rate	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
			tensor, zy component		
spf.rrijxz	0.5*(uz-wx)	1/s	Rotation rate tensor, xz component	Domains 1–2	
spf.rrijyz	0.5*(vz-wy)	1/s	Rotation rate tensor, yz component	Domains 1–2	
spf.rrijzz	0	1/s	Rotation rate tensor, zz component	Domains 1–2	
spf.sr	sqrt(2*spf.srijxx^2+2*spf.srijxy^2+2*spf.srijxz^2+2*spf.srijyx^2+2*spf.srijyy^2+2*spf.srijyz^2+2*spf.srijzx^2+2*spf.srijzy^2+2*spf.srijzz^2+eps)	1/s	Shear rate	Domains 1–2	
spf.rr	sqrt(2*spf.rrijxx^2+2*spf.rrijxy^2+2*spf.rrijxz^2+2*spf.rrijyx^2+2*spf.rrijyy^2+2*spf.rrijyz^2+2*spf.rrijzx^2+2*spf.rrijzy^2+2*spf.rrijzz^2+eps)	1/s	Rotation rate	Domains 1–2	
spf.divu	ux+vy+wz	1/s	Divergence of velocity field	Domains 1–2	
spf.Fx	spf.rho*(u*d(d(x,TIME),X)+v*d(d(y,TIME),X)+w*d(d(z,TIME),X))	N/m^3	Volume force, x component	Domain 2	+ operation
spf.Fy	spf.rho*(u*d(d(x,TIME),Y)+v*d(d(y,TIME),Y)+w*d(d(z,TIME),Y))	N/m^3	Volume force, y component	Domain 2	+ operation
spf.Fz	spf.rho*(u*d(d(x,TIME),Z)+v*d(d(y,TIME),Z)+w*d(d(z,TIME),Z))	N/m^3	Volume force, z component	Domain 2	+ operation
spf.Fx	0	N/m^3	Volume force, x component	Domain 1	+ operation
spf.Fy	0	N/m^3	Volume force, y component	Domain 1	+ operation
spf.Fz	0	N/m^3	Volume force, z component	Domain 1	+ operation
spf.U	sqrt(u^2+v^2+w^2)	m/s	Velocity	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
			magnitude		
spf.vorticityx	wy-vz	1/s	Vorticity field, x component	Domains 1–2	
spf.vorticityy	-wx+uz	1/s	Vorticity field, y component	Domains 1–2	
spf.vorticityz	vx-uy	1/s	Vorticity field, z component	Domains 1–2	
spf.vort_magn	sqrt(spf.vorticityx^2+spf.vorticityy^2+spf.vorticityz^2)	1/s	Vorticity magnitude	Domains 1–2	
spf.cellRe	0.25*spf.rho*sqrt(emetric_spatial(u-d(x,TIME),v-d(y,TIME),w-d(z,TIME))/emetric2_spatial)/spf.mu	1	Cell Reynolds number	Domains 1–2	
spf.nu	spf.mu/spf.rho	m²/s	Kinematic viscosity	Domains 1–2	
spf.betaT	0	1/Pa	Isothermal compressibility coefficient	Domains 1–2	
spf.Qm	0	kg/(m³·s)	Source term	Domains 1–2	+ operation
spf.mu_eff	spf.mu+spf.muT	Pa·s	Dynamic viscosity	Domains 1–2	
spf.muT	nojac(max(spf.rho*spf.lsubstar*sqrt(spf.k_nn),0.5*spf.mu))	Pa·s	Turbulent dynamic viscosity	Domains 1–2	
spf.T_stressx	spf.K_stressx-p2*spf.nxmesh	N/m²	Total stress, x component	Boundaries 1–114	+ operation
spf.T_stressy	spf.K_stressy-p2*spf.nymesh	N/m²	Total stress, y component	Boundaries 1–114	+ operation
spf.T_stressz	spf.K_stressz-p2*spf.nzmesh	N/m²	Total stress, z component	Boundaries 1–114	+ operation
spf.K_stressx	spf.mu_eff*(2*ux*spf.nxmesh+(uy+vx)*spf.nymesh+(uz+wx)*spf.nzmesh)	N/m²	Viscous stress, x component	Boundaries 1–114	+ operation
spf.K_stressy	spf.mu_eff*((vx+uy)*spf.nxmesh+2*vy*spf.nymesh+(vz+wy)*spf.nzmesh)	N/m²	Viscous stress, y component	Boundaries 1–114	+ operation
spf.K_stressz	spf.mu_eff*((wx+uz)*	N/m²	Viscous stress, z	Boundaries 1–	+ operation

Name	Expression	Unit	Description	Selection	Details
	spf.nxmesh+(wy+vz)*spf.nymesh+2*wz*spf.nzmesh)		component	114	
spf.K_stress_tensorxx	2*spf.mu_eff*ux	N/m²	Viscous stress tensor, xx component	Domains 1–2	+ operation
spf.K_stress_tensoryx	spf.mu_eff*(vx+uy)	N/m²	Viscous stress tensor, yx component	Domains 1–2	+ operation
spf.K_stress_tensorzx	spf.mu_eff*(wx+uz)	N/m²	Viscous stress tensor, zx component	Domains 1–2	+ operation
spf.K_stress_tensorxy	spf.mu_eff*(uy+vx)	N/m²	Viscous stress tensor, xy component	Domains 1–2	+ operation
spf.K_stress_tensoryy	2*spf.mu_eff*vy	N/m²	Viscous stress tensor, yy component	Domains 1–2	+ operation
spf.K_stress_tensorzy	spf.mu_eff*(wy+vz)	N/m²	Viscous stress tensor, zy component	Domains 1–2	+ operation
spf.K_stress_tensorxz	spf.mu_eff*(uz+wx)	N/m²	Viscous stress tensor, xz component	Domains 1–2	+ operation
spf.K_stress_tensoryz	spf.mu_eff*(vz+wy)	N/m²	Viscous stress tensor, yz component	Domains 1–2	+ operation
spf.K_stress_tensorzz	2*spf.mu_eff*wz	N/m²	Viscous stress tensor, zz component	Domains 1–2	+ operation
spf.K_stress_tensor_testxx	2*spf.mu_eff*test(ux)	N/m²	Viscous stress tensor test, xx component	Domains 1–2	+ operation
spf.K_stress_tensor_testyx	spf.mu_eff*(test(vx)+test(uy))	N/m²	Viscous stress tensor test, yx component	Domains 1–2	+ operation
spf.K_stress_tensor_testzx	spf.mu_eff*(test(wx)+test(uz))	N/m²	Viscous stress tensor test, zx component	Domains 1–2	+ operation
spf.K_stress_tensor_testxy	spf.mu_eff*(test(uy)+test(vx))	N/m²	Viscous stress tensor test, xy component	Domains 1–2	+ operation
spf.K_stress_tenso	2*spf.mu_eff*test(vy)	N/m²	Viscous stress	Domains 1–2	+ operation

Name	Expression	Unit	Description	Selection	Details
r_testyy			tensor test, yy component		
spf.K_stress_tensor_testzy	spf.mu_eff*(test(wy)+test(vz))	N/m²	Viscous stress tensor test, zy component	Domains 1–2	+ operation
spf.K_stress_tensor_testxz	spf.mu_eff*(test(uz)+test(wx))	N/m²	Viscous stress tensor test, xz component	Domains 1–2	+ operation
spf.K_stress_tensor_testyz	spf.mu_eff*(test(vz)+test(wy))	N/m²	Viscous stress tensor test, yz component	Domains 1–2	+ operation
spf.K_stress_tensor_testzz	2*spf.mu_eff*test(wz)	N/m²	Viscous stress tensor test, zz component	Domains 1–2	+ operation
spf.upwind_helpx	u-d(x,TIME)	m/s	Upwind term, x component	Domains 1–2	+ operation
spf.upwind_helpy	v-d(y,TIME)	m/s	Upwind term, y component	Domains 1–2	+ operation
spf.upwind_helpz	w-d(z,TIME)	m/s	Upwind term, z component	Domains 1–2	+ operation
spf.muinit	subst(material.mu,spf.fp1.minput_temperature,spf.Tref,spf.fp1.minput_pressure,spf.pref)	Pa·s	Dynamic viscosity	Domains 1–2	Meta
spf.rhoinit	spf.rho	kg/m³	Density	Domains 1–2	
spf.l_mix_lim	2*spf.lref	m	Mixing length limit	Domains 1–2	
spf.k_pos	spf.k_nn+eps	m²/s²	Regularized turbulent kinetic energy	Domains 1–2	
spf.ep_nn	max(ep2,0)	m²/s³	Regularized turbulent dissipation rate	Domains 1–2	
spf.ep_pos	spf.ep_nn+eps	m²/s³		Domains 1–2	
spf.Sxx	ux	1/s	Strain rate, xx component	Domains 1–2	+ operation
spf.Syx	0.5*(vx+uy)	1/s	Strain rate, yx component	Domains 1–2	+ operation
spf.Szx	0.5*(wx+uz)	1/s	Strain rate, zx component	Domains 1–2	+ operation
spf.Sxy	0.5*(uy+vx)	1/s	Strain rate, xy	Domains 1–2	+ operation

Name	Expression	Unit	Description	Selection	Details
			component		
spf.Syy	vy	1/s	Strain rate, yy component	Domains 1–2	+ operation
spf.Szy	0.5*(wy+vz)	1/s	Strain rate, zy component	Domains 1–2	+ operation
spf.Sxz	0.5*(uz+wx)	1/s	Strain rate, xz component	Domains 1–2	+ operation
spf.Syz	0.5*(vz+wy)	1/s	Strain rate, yz component	Domains 1–2	+ operation
spf.Szz	wz	1/s	Strain rate, zz component	Domains 1–2	+ operation
spf.AbsS	sqrt(max(spf.Sxx^2+spf.Sxy^2+spf.Sxz^2+spf.Syx^2+spf.Syy^2+spf.Syz^2+spf.Szx^2+spf.Szy^2+spf.Szz^2,0))	1/s	Absolute strain rate	Domains 1–2	
spf.rF	sqrt(1/6)/max(spf.AbsS,eps)	s	Help variable	Domains 1–2	
spf.rFInv	sqrt(6)*spf.AbsS	1/s	Help variable	Domains 1–2	
spf.lcore	min(spf.C_mu*spf.k_nn^1.5/spf.ep_pos,sqrt(spf.k_nn)*spf.rF)	m	Help variable	Domains 1–2	
spf.lsubstar	nojac(min(spf.lcore,spf.l_mix_lim))	m	Limited mixing length	Domains 1–2	
spf.nuT	spf.muT/spf.rho	m^2/s	Turbulent kinematic viscosity	Domains 1–2	
spf.linSCk	-spf.rho*(spf.gammaT-min(spf.Pkb_mul,0)/max(spf.rho,eps))	$kg/(m^3 \cdot s)$	Linear source term coefficient, k-equation	Domains 1–2	
spf.linSCeps	-spf.rho*(spf.Ceps2*spf.gammaT-min(spf.Pepb_mul,0)/max(spf.rho,eps))	$kg/(m^3 \cdot s)$	Linear source term coefficient	Domains 1–2	
spf.PCore	2*ux^2+uy*(uy+vx)+uz*(uz+wx)+vx*(uy+vx)+2*vy^2+vz*(vz+wy)+wx*(uz+wx)+wy*(vz+wy)+2*wz^2	$1/s^2$	Turbulent kinetic energy source term	Domains 1–2	+ operation

Name	Expression	Unit	Description	Selection	Details
spf.Pk	nojac(max(spf.muT*spf.PCore,0))+nojac(max(spf.Pkb_mul,0)*k2)	W/m³	Turbulent kinetic energy source term	Domains 1–2	
spf.Peps	nojac(max(spf.Ceps1*spf.gammaT*spf.muT*spf.PCore,0))+nojac(max(spf.Pepb_mul,0)*ep2)	Pa/s²		Domains 1–2	
spf.kinit	(10*spf.muinit/(spf.rhoinit*spf.l_mix_lim))^2	m²/s²	Turbulent kinetic energy	Domains 1–2	
spf.epinit	10*spf.C_mu*spf.kinit^1.5/spf.l_mix_lim	m²/s³	Turbulent dissipation rate	Domains 1–2	
spf.gammaT	nojac(spf.C_mu*spf.rho*spf.k_nn/spf.muT)	1/s	Turbulence help variable	Domains 1–2	
spf.tauT	spf.muT/nojac(spf.C_mu*spf.rho*spf.k_pos)	s	Turbulence time scale	Domains 1–2	
spf.ep_global	ep2	m²/s³	Turbulent dissipation rate, (all cells)	Domains 1–2	
spf.Pkb	spf.Pkb_mul*k2	W/m³	Buoyancy-induced production of turbulence kinetic energy	Domains 1–2	+ operation
spf.Pkb_mul	0	kg/(m³·s)	Help variable	Domains 1–2	+ operation
spf.Pepb_mul	0	kg/(m³·s)	Help variable	Domains 1–2	+ operation
k2xt	k2xTIME-k2xx*d(x,TIME)-k2xy*d(y,TIME)-k2xz*d(z,TIME)	m/s³	Gradient of k2, x component, first time derivative	Domains 1–2	
k2yt	k2yTIME-k2yx*d(x,TIME)-k2yy*d(y,TIME)-k2yz*d(z,TIME)	m/s³	Gradient of k2, y component, first time derivative	Domains 1–2	
k2zt	k2zTIME-k2zx*d(x,TIME)-k2zy*d(y,TIME)-k2zz*d(z,TIME)	m/s³	Gradient of k2, z component, first time derivative	Domains 1–2	
k2xtt	d(k2xTIME-	m/s⁴	Gradient of k2, x	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	k2xx*d(x,TIME)-k2xy*d(y,TIME)-k2xz*d(z,TIME),TIME)-d(k2xTIME-k2xx*d(x,TIME)-k2xy*d(y,TIME)-k2xz*d(z,TIME),x)*d(x,TIME)-d(k2xTIME-k2xx*d(x,TIME)-k2xy*d(y,TIME)-k2xz*d(z,TIME),y)*d(y,TIME)-d(k2xTIME-k2xx*d(x,TIME)-k2xy*d(y,TIME)-k2xz*d(z,TIME),z)*d(z,TIME)		component, second time derivative		
k2ytt	d(k2yTIME-k2yx*d(x,TIME)-k2yy*d(y,TIME)-k2yz*d(z,TIME),TIME)-d(k2yTIME-k2yx*d(x,TIME)-k2yy*d(y,TIME)-k2yz*d(z,TIME),x)*d(x,TIME)-d(k2yTIME-k2yx*d(x,TIME)-k2yy*d(y,TIME)-k2yz*d(z,TIME),y)*d(y,TIME)-d(k2yTIME-k2yx*d(x,TIME)-k2yy*d(y,TIME)-k2yz*d(z,TIME),z)*d(z,TIME)	m/s^4	Gradient of k2, y component, second time derivative	Domains 1–2	
k2ztt	d(k2zTIME-k2zx*d(x,TIME)-k2zy*d(y,TIME)-k2zz*d(z,TIME),TIME)-d(k2zTIME-k2zx*d(x,TIME)-k2zy*d(y,TIME)-k2zz*d(z,TIME),x)*d(x,TIME)-d(k2zTIME-k2zx*d(x,TIME)-k2zy*d(y,TIME)-k2zz*d(z,TIME),y)*d(y,TIME)-d(k2zTIME-k2zx*d(x,TIME)-	m/s^4	Gradient of k2, z component, second time derivative	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	k2zy*d(y,TIME)-k2zz*d(z,TIME),z)*d(z,TIME)				
k2t	k2TIME-k2x*d(x,TIME)-k2y*d(y,TIME)-k2z*d(z,TIME)	m^2/s^3	Turbulent kinetic energy, first time derivative	Domains 1–2	
k2tt	d(k2TIME-k2x*d(x,TIME)-k2y*d(y,TIME)-k2z*d(z,TIME),TIME)-d(k2TIME-k2x*d(x,TIME)-k2y*d(y,TIME)-k2z*d(z,TIME),x)*d(x,TIME)-d(k2TIME-k2x*d(x,TIME)-k2y*d(y,TIME)-k2z*d(z,TIME),y)*d(y,TIME)-d(k2TIME-k2x*d(x,TIME)-k2y*d(y,TIME)-k2z*d(z,TIME),z)*d(z,TIME)	m^2/s^4	Turbulent kinetic energy, second time derivative	Domains 1–2	
ep2xt	ep2xTIME-ep2xx*d(x,TIME)-ep2xy*d(y,TIME)-ep2xz*d(z,TIME)	m/s^4	Gradient of ep2, x component, first time derivative	Domains 1–2	
ep2yt	ep2yTIME-ep2yx*d(x,TIME)-ep2yy*d(y,TIME)-ep2yz*d(z,TIME)	m/s^4	Gradient of ep2, y component, first time derivative	Domains 1–2	
ep2zt	ep2zTIME-ep2zx*d(x,TIME)-ep2zy*d(y,TIME)-ep2zz*d(z,TIME)	m/s^4	Gradient of ep2, z component, first time derivative	Domains 1–2	
ep2xtt	d(ep2xTIME-ep2xx*d(x,TIME)-ep2xy*d(y,TIME)-ep2xz*d(z,TIME),TIME)-d(ep2xTIME-ep2xx*d(x,TIME)-ep2xy*d(y,TIME)-ep2xz*d(z,TIME),x)*d(x,TIME)-d(ep2xTIME-	m/s^5	Gradient of ep2, x component, second time derivative	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	ep2xx*d(x,TIME)-ep2xy*d(y,TIME)-ep2xz*d(z,TIME),y)*d(y,TIME)-d(ep2xTIME-ep2xx*d(x,TIME)-ep2xy*d(y,TIME)-ep2xz*d(z,TIME),z)*d(z,TIME)				
ep2ytt	d(ep2yTIME-ep2yx*d(x,TIME)-ep2yy*d(y,TIME)-ep2yz*d(z,TIME),TIME)-d(ep2yTIME-ep2yx*d(x,TIME)-ep2yy*d(y,TIME)-ep2yz*d(z,TIME),x)*d(x,TIME)-d(ep2yTIME-ep2yx*d(x,TIME)-ep2yy*d(y,TIME)-ep2yz*d(z,TIME),y)*d(y,TIME)-d(ep2yTIME-ep2yx*d(x,TIME)-ep2yy*d(y,TIME)-ep2yz*d(z,TIME),z)*d(z,TIME)	m/s^5	Gradient of ep2, y component, second time derivative	Domains 1–2	
ep2ztt	d(ep2zTIME-ep2zx*d(x,TIME)-ep2zy*d(y,TIME)-ep2zz*d(z,TIME),TIME)-d(ep2zTIME-ep2zx*d(x,TIME)-ep2zy*d(y,TIME)-ep2zz*d(z,TIME),x)*d(x,TIME)-d(ep2zTIME-ep2zx*d(x,TIME)-ep2zy*d(y,TIME)-ep2zz*d(z,TIME),y)*d(y,TIME)-d(ep2zTIME-ep2zx*d(x,TIME)-ep2zy*d(y,TIME)-ep2zz*d(z,TIME),z)*d(z,TIME)	m/s^5	Gradient of ep2, z component, second time derivative	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
ep2t	ep2TIME-ep2x*d(x,TIME)-ep2y*d(y,TIME)-ep2z*d(z,TIME)	m^2/s^4	Turbulent dissipation rate, first time derivative	Domains 1–2	
ep2tt	d(ep2TIME-ep2x*d(x,TIME)-ep2y*d(y,TIME)-ep2z*d(z,TIME),TIME)-d(ep2TIME-ep2x*d(x,TIME)-ep2y*d(y,TIME)-ep2z*d(z,TIME),x)*d(x,TIME)-d(ep2TIME-ep2x*d(x,TIME)-ep2y*d(y,TIME)-ep2z*d(z,TIME),y)*d(y,TIME)-d(ep2TIME-ep2x*d(x,TIME)-ep2y*d(y,TIME)-ep2z*d(z,TIME),z)*d(z,TIME)	m^2/s^5	Turbulent dissipation rate, second time derivative	Domains 1–2	
spf.tau_vdxx	2*spf.srijxx*(spf.mu+spf.muT)	Pa	Viscous stress tensor, xx component	Domains 1–2	+ operation
spf.tau_vdyx	2*spf.srijyx*(spf.mu+spf.muT)	Pa	Viscous stress tensor, yx component	Domains 1–2	+ operation
spf.tau_vdzx	2*spf.srijzx*(spf.mu+spf.muT)	Pa	Viscous stress tensor, zx component	Domains 1–2	+ operation
spf.tau_vdxy	2*spf.srijxy*(spf.mu+spf.muT)	Pa	Viscous stress tensor, xy component	Domains 1–2	+ operation
spf.tau_vdyy	2*spf.srijyy*(spf.mu+spf.muT)	Pa	Viscous stress tensor, yy component	Domains 1–2	+ operation
spf.tau_vdzy	2*spf.srijzy*(spf.mu+spf.muT)	Pa	Viscous stress tensor, zy component	Domains 1–2	+ operation
spf.tau_vdxz	2*spf.srijxz*(spf.mu+spf.muT)	Pa	Viscous stress tensor, xz component	Domains 1–2	+ operation
spf.tau_vdyz	2*spf.srijyz*(spf.mu+spf.muT)	Pa	Viscous stress tensor, yz	Domains 1–2	+ operation

Name	Expression	Unit	Description	Selection	Details
			component		
spf.tau_vdzz	2*spf.srijzz*(spf.mu+spf.muT)	Pa	Viscous stress tensor, zz component	Domains 1–2	+ operation
spf.Qvd	spf.tau_vdxx*ux+spf.tau_vdxy*uy+spf.tau_vdxz*uz+spf.tau_vdyx*vx+spf.tau_vdyy*vy+spf.tau_vdyz*vz+spf.tau_vdzx*wx+spf.tau_vdzy*wy+spf.tau_vdzz*wz	W/m³	Viscous dissipation	Domains 1–2	+ operation
spf.epsilon_p	1	1	Porosity	Domains 1–2	
spf.Fst_tensorxx	0	N/m²	Surface tension force, xx component	Domains 1–2	+ operation
spf.Fst_tensoryx	0	N/m²	Surface tension force, yx component	Domains 1–2	+ operation
spf.Fst_tensorzx	0	N/m²	Surface tension force, zx component	Domains 1–2	+ operation
spf.Fst_tensorxy	0	N/m²	Surface tension force, xy component	Domains 1–2	+ operation
spf.Fst_tensoryy	0	N/m²	Surface tension force, yy component	Domains 1–2	+ operation
spf.Fst_tensorzy	0	N/m²	Surface tension force, zy component	Domains 1–2	+ operation
spf.Fst_tensorxz	0	N/m²	Surface tension force, xz component	Domains 1–2	+ operation
spf.Fst_tensoryz	0	N/m²	Surface tension force, yz component	Domains 1–2	+ operation
spf.Fst_tensorzz	0	N/m²	Surface tension force, zz component	Domains 1–2	+ operation
spf.continuityEquation	spf.rho*spf.divu	kg/(m³·s)	Continuity equation	Domains 1–2	
spf.contCoeff	spf.rho	kg/m³	Help variable	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
spf.lref	0.032587500000000005	m	Reference length	Domains 1–2	
spf.res_k	spf.rho*(k2TIME-k2x*d(x,TIME)-k2y*d(y,TIME)-k2z*d(z,TIME))-(spf.mu+spf.muT/spf.sigmak)*(k2xx+k2yy+k2zz)+spf.rho*u*k2x+spf.rho*v*k2y+spf.rho*w*k2z-spf.linSCk*k2-spf.Pk	W/m^3	Turbulent kinetic energy equation residual	Domains 1–2	
spf.res_ep	spf.rho*(ep2TIME-ep2x*d(x,TIME)-ep2y*d(y,TIME)-ep2z*d(z,TIME))-(spf.mu+spf.muT/spf.sigmaeps)*(ep2xx+ep2yy+ep2zz)+spf.rho*u*ep2x+spf.rho*v*ep2y+spf.rho*w*ep2z-spf.linSCeps*ep2-spf.Peps	Pa/s^2	Turbulent dissipation rate equation residual	Domains 1–2	
spf.res_u	spf.rho*(uTIME-d(u,x)*d(x,TIME)-d(u,y)*d(y,TIME)-d(u,z)*d(z,TIME))+p2x+spf.rho*u*ux+spf.rho*v*uy+spf.rho*w*uz-(d(2*ux,x)+d(uy+vx,y)+d(uz+wx,z))*(spf.mu+spf.muT)-spf.Fx-spf.Fgtotx	N/m^3	Equation residual	Domains 1–2	
spf.res_v	spf.rho*(vTIME-d(v,x)*d(x,TIME)-d(v,y)*d(y,TIME)-d(v,z)*d(z,TIME))+spf.rho*u*vx+p2y+spf.rho*v*vy+spf.rho*w*vz-(d(vx+uy,x)+d(2*vy,y)+d(vz+wy,z))*(spf.mu+spf.muT)-spf.Fy-spf.Fgtoty	N/m^3	Equation residual	Domains 1–2	
spf.res_w	spf.rho*(wTIME-	N/m^3	Equation residual	Domains 1–2	

Name	Expression	Unit	Description	Selection	Details
	d(w,x)*d(x,TIME)-d(w,y)*d(y,TIME)-d(w,z)*d(z,TIME))+spf.rho*u*wx+spf.rho*v*wy+p2z+spf.rho*w*wz-(d(wx+uz,x)+d(wy+vz,y)+d(2*wz,z))*(spf.mu+spf.muT)-spf.Fz-spf.Fgtotz				
spf.res_p	spf.rho*spf.divu	kg/(m³·s)	Pressure equation residual	Domains 1–2	

Shape functions

Name	Shape function	Unit	Description	Shape frame	Selection
u	Lagrange (Linear)	m/s	Velocity field, x component	Spatial	Domains 1–2
v	Lagrange (Linear)	m/s	Velocity field, y component	Spatial	Domains 1–2
w	Lagrange (Linear)	m/s	Velocity field, z component	Spatial	Domains 1–2
p2	Lagrange (Linear)	Pa	Pressure	Spatial	Domains 1–2
k2	Lagrange (Linear)	m^2/s^2	Turbulent kinetic energy	Spatial	Domains 1–2
ep2	Lagrange (Linear)	m^2/s^3	Turbulent dissipation rate	Spatial	Domains 1–2

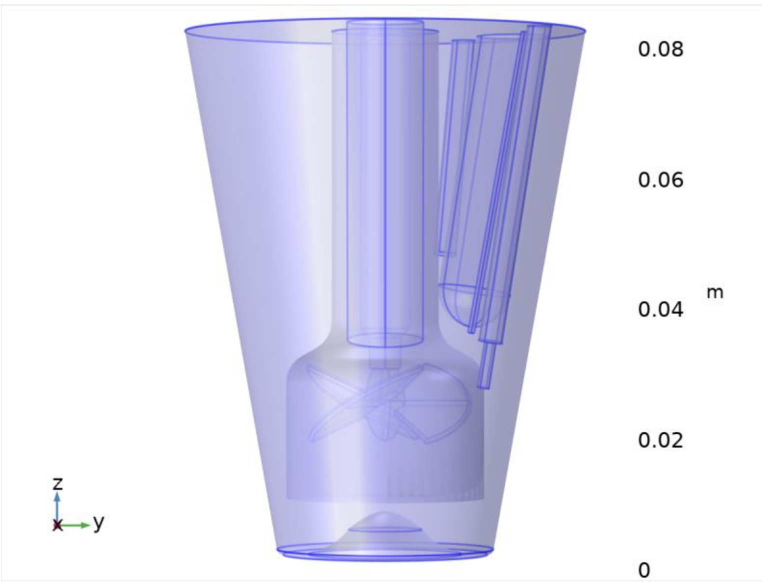
Weak expressions

Weak expression	Integration order	Integration frame	Selection
spf.rho*(-(uTIME-ux*d(x,TIME)-uy*d(y,TIME)-uz*d(z,TIME))*test(u)-(vTIME-vx*d(x,TIME)-vy*d(y,TIME)-vz*d(z,TIME))*test(v)-(wTIME-wx*d(x,TIME)-wy*d(y,TIME)-wz*d(z,TIME))*test(w))	2	Spatial	Domains 1–2
(p2-spf.K_stress_tensorxx)*test(ux)-spf.K_stress_tensorxy*test(uy)-spf.K_stress_tensorxz*test(uz)-spf.K_stress_tensoryx*test(vx)+(p2-spf.K_stress_tensoryy)*test(vy)-spf.K_stress_tensoryz*test(vz)-spf.K_stress_tensorzx*test(wx)-spf.K_stress_tensorzy*test(wy)+(p2-	2	Spatial	Domains 1–2

Weak expression	Integration order	Integration frame	Selection
spf.K_stress_tensorzz)*test(wz)			
spf.Fx*test(u)+spf.Fy*test(v)+spf.Fz*test(w)	2	Spatial	Domains 1–2
spf.rho*(-(d(u,x)*u+d(u,y)*v+d(u,z)*w)*test(u)-(d(v,x)*u+d(v,y)*v+d(v,z)*w)*test(v)-(d(w,x)*u+d(w,y)*v+d(w,z)*w)*test(w))	2	Spatial	Domains 1–2
-spf.continuityEquation*test(p2)	2	Spatial	Domains 1–2
-test(k2x)*(spf.mu+spf.muT/spf.sigmak)*k2x-test(k2y)*(spf.mu+spf.muT/spf.sigmak)*k2y-test(k2z)*(spf.mu+spf.muT/spf.sigmak)*k2z-spf.rho*(u*k2x+v*k2y+w*k2z)*test(k2)+spf.Pk*test(k2)+spf.linSCk*k2*test(k2)	2	Spatial	Domains 1–2
-spf.rho*(k2TIME-k2x*d(x,TIME)-k2y*d(y,TIME)-k2z*d(z,TIME))*test(k2)	2	Spatial	Domains 1–2
-(k2-nojac(k2))*(spf.usePseudoTimeStepping>0)*spf.rho*spf.tsti*test(k2)	2	Spatial	Domains 1–2
-test(ep2x)*(spf.mu+spf.muT/spf.sigmaeps)*ep2x-test(ep2y)*(spf.mu+spf.muT/spf.sigmaeps)*ep2y-test(ep2z)*(spf.mu+spf.muT/spf.sigmaeps)*ep2z-spf.rho*(u*ep2x+v*ep2y+w*ep2z)*test(ep2)+spf.Peps*test(ep2)+spf.linSCeps*ep2*test(ep2)	2	Spatial	Domains 1–2
-spf.rho*(ep2TIME-ep2x*d(x,TIME)-ep2y*d(y,TIME)-ep2z*d(z,TIME))*test(ep2)	2	Spatial	Domains 1–2
-(ep2-nojac(ep2))*(spf.usePseudoTimeStepping>0)*spf.rho*spf.tsti*test(ep2)	2	Spatial	Domains 1–2
-spf.crosswindep-spf.crosswindk	2	Spatial	Domains 1–2
spf.streamlinek	2	Spatial	Domains 1–2

Weak expression	Integration order	Integration frame	Selection
spf.streamlineep	2	Spatial	Domains 1–2
spf.streamlinens	2	Spatial	Domains 1–2
spf.crosswindns	2	Spatial	Domains 1–2
(spf.usePseudoTimeStepping>0)*spf.rho*spf.tsti*(-(u-nojac(u))*test(u)-(v-nojac(v))*test(v)-(w-nojac(w))*test(w))	2	Spatial	Domains 1–2

2.4.4 Initial Values 1



Initial Values 1

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: All domains

EQUATIONS

$$p_{\mathrm{init}} = p + p_{\mathrm{hydro}}$$
$$p_{\mathrm{hydro}} = \rho_{\mathrm{ref}}\, \mathbf{g} \cdot (\mathbf{r} - \mathbf{r}_{\mathrm{ref}})$$

Initial values

SETTINGS

Description	Value
Velocity field, x component	0
Velocity field, y component	0
Velocity field, z component	0

Description	Value
Pressure	0
Compensate for hydrostatic pressure	On
Turbulent kinetic energy	spf.kinit
Turbulent dissipation rate	spf.epinit

Coordinate system selection

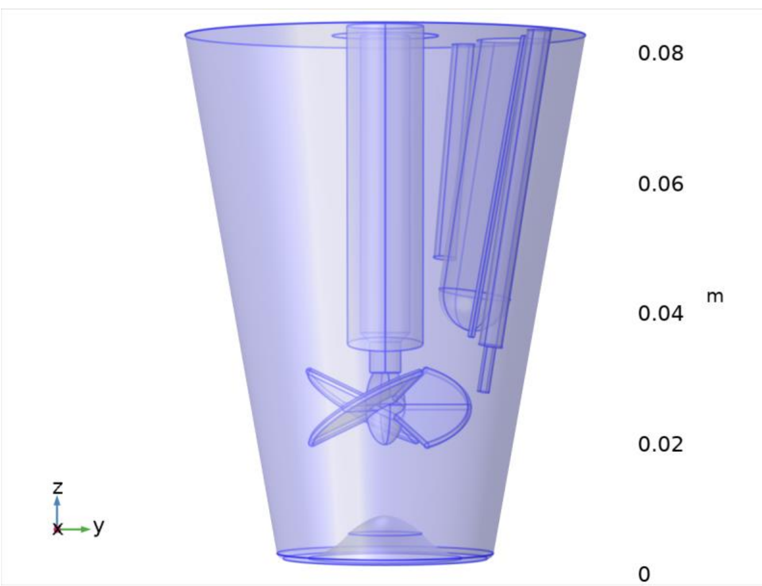
SETTINGS

Description	Value
Coordinate system	Global coordinate system

Variables

Name	Expression	Unit	Description	Selection
spf.u_initx	0	m/s	Velocity field, x component	Domains 1–2
spf.u_inity	0	m/s	Velocity field, y component	Domains 1–2
spf.u_initz	0	m/s	Velocity field, z component	Domains 1–2
spf.p_init	spf.p_hydro	Pa	Pressure	Domains 1–2
spf.k_init	spf.kinit	m^2/s^2	Turbulent kinetic energy	Domains 1–2
spf.ep_init	spf.epinit	m^2/s^3	Turbulent dissipation rate	Domains 1–2

2.4.5 Wall 1



Wall 1

SELECTION

Geometric entity level	Boundary

Selection	Geometry geom1: Dimension 2: All boundaries

EQUATIONS

$$\mathbf{u}\cdot\mathbf{n}=\mathbf{u}_{\mathrm{tr}}\cdot\mathbf{n}$$

$$\mathbf{K}\mathbf{n}=-\rho\frac{u_{\tau}}{u^{+}}\mathbf{u}_{\mathrm{rel,\,tang}}$$

$$\mathbf{u}_{\mathrm{rel}}=\mathbf{u}-\mathbf{u}_{\mathrm{tr}},\ \ \mathbf{u}_{\mathrm{rel,\,tang}}=\mathbf{u}_{\mathrm{rel}}-(\mathbf{u}_{\mathrm{rel}}\cdot\mathbf{n})\mathbf{n}$$

$$\nabla k2\cdot\mathbf{n}=0,\ \ \epsilon=\rho\frac{C_{\mu}k2^{2}}{\kappa_{v}\delta_{w}^{+}\mu}$$

Boundary condition

SETTINGS

Description	Value
Wall condition	No slip
Apply wall roughness	Off

Wall movement

SETTINGS

Description	Value
Translational velocity	Automatic from frame
Sliding wall	Off

Variables

Name	Expression	Unit	Description	Selection	Details
spf.hasWF	1		Help variable	Boundaries 1–11, 13–40, 42–114	
spf.k_nn	max(k2,0)	m^2/s^2	Regularized turbulent kinetic energy	Boundaries 1–11, 13–40, 42–114	
spf.ubndx	spf.utrx+spf.usx	m/s	Velocity at boundary, x component	Boundaries 1–11, 13–40, 42–114	
spf.ubndy	spf.utry+spf.usy	m/s	Velocity at boundary, y component	Boundaries 1–11, 13–40, 42–114	
spf.ubndz	spf.utrz+spf.usz	m/s	Velocity at boundary, z component	Boundaries 1–11, 13–40, 42–114	
spf.usx	0	m/s	Velocity of sliding wall, x component	Boundaries 1–11, 13–40, 42–114	

Name	Expression	Unit	Description	Selection	Details
spf.usy	0	m/s	Velocity of sliding wall, y component	Boundaries 1–11, 13–40, 42–114	
spf.usz	0	m/s	Velocity of sliding wall, z component	Boundaries 1–11, 13–40, 42–114	
spf.utrx	d(x,TIME)	m/s	Velocity of moving wall, x component	Boundaries 42–114	
spf.utry	d(y,TIME)	m/s	Velocity of moving wall, y component	Boundaries 42–114	
spf.utrz	d(z,TIME)	m/s	Velocity of moving wall, z component	Boundaries 42–114	
spf.utrx	0	m/s	Velocity of moving wall, x component	Boundaries 1–11, 13–40	
spf.utry	0	m/s	Velocity of moving wall, y component	Boundaries 1–11, 13–40	
spf.utrz	0	m/s	Velocity of moving wall, z component	Boundaries 1–11, 13–40	
spf.uLeakagex	0	m/s	Leakage velocity, x component	Boundaries 1–11, 13–40, 42–114	+ operation
spf.uLeakagey	0	m/s	Leakage velocity, y component	Boundaries 1–11, 13–40, 42–114	+ operation
spf.uLeakagez	0	m/s	Leakage velocity, z component	Boundaries 1–11, 13–40, 42–114	+ operation
spf.noSlipWall	1	1	Help variable	Boundaries 1–11, 13–40, 42–114	
spf.un_here	u*nojac(spf.nxmesh)+v*nojac(spf.nymesh)+w*nojac(spf.nzmesh)	m/s	Intermediate variable	Boundaries 1–11, 13–40, 42–114	
spf.u_herex	spf.un_here*nojac(spf.nxmesh)	m/s	Intermediate variable, x component	Boundaries 1–11, 13–40, 42–114	
spf.u_herey	spf.un_here*nojac(spf.	m/s	Intermediate	Boundaries 1–	

Name	Expression	Unit	Description	Selection	Details
	nymesh)		variable, y component	11, 13–40, 42–114	
spf.u_herez	spf.un_here*nojac(spf.nzmesh)	m/s	Intermediate variable, z component	Boundaries 1–11, 13–40, 42–114	
spf.un_there	(spf.ubndx+spf.uLeakagex)*nojac(spf.nxmesh)+(spf.ubndy+spf.uLeakagey)*nojac(spf.nymesh)+(spf.ubndz+spf.uLeakagez)*nojac(spf.nzmesh)	m/s	Intermediate variable	Boundaries 1–11, 13–40, 42–114	
spf.u_therex	spf.un_there*nojac(spf.nxmesh)	m/s	Intermediate variable, x component	Boundaries 1–11, 13–40, 42–114	
spf.u_therey	spf.un_there*nojac(spf.nymesh)	m/s	Intermediate variable, y component	Boundaries 1–11, 13–40, 42–114	
spf.u_therez	spf.un_there*nojac(spf.nzmesh)	m/s	Intermediate variable, z component	Boundaries 1–11, 13–40, 42–114	
spf.unJump	spf.un_here-spf.un_there	m/s	Jump in normal velocity	Boundaries 1–11, 13–40, 42–114	
spf.KStressn_avx	spf.K_stress_tensorxx*spf.nxmesh+spf.K_stress_tensorxy*spf.nymesh+spf.K_stress_tensorxz*spf.nzmesh	N/m^2	Average viscous stress, x component	Boundaries 1–11, 13–40, 42–114	
spf.KStressn_avy	spf.K_stress_tensoryx*spf.nxmesh+spf.K_stress_tensoryy*spf.nymesh+spf.K_stress_tensoryz*spf.nzmesh	N/m^2	Average viscous stress, y component	Boundaries 1–11, 13–40, 42–114	
spf.KStressn_avz	spf.K_stress_tensorzx*spf.nxmesh+spf.K_stress_tensorzy*spf.nymesh+spf.K_stress_tensorzz*spf.nzmesh	N/m^2	Average viscous stress, z component	Boundaries 1–11, 13–40, 42–114	
spf.KStressTestn_avx	spf.K_stress_tensor_testxx*spf.nxmesh+spf.K_stress_tensor_testxy*spf.nymesh+spf.K_stress_tensor_testxz*spf	N/m^2	Average viscous stress, x component	Boundaries 1–11, 13–40, 42–114	

Name	Expression	Unit	Description	Selection	Details
	.nzmesh				
spf.KStressTestn_avy	spf.K_stress_tensor_testyx*spf.nxmesh+spf.K_stress_tensor_testyy*spf.nymesh+spf.K_stress_tensor_testyz*spf.nzmesh	N/m^2	Average viscous stress, y component	Boundaries 1–11, 13–40, 42–114	
spf.KStressTestn_avz	spf.K_stress_tensor_testzx*spf.nxmesh+spf.K_stress_tensor_testzy*spf.nymesh+spf.K_stress_tensor_testzz*spf.nzmesh	N/m^2	Average viscous stress, z component	Boundaries 1–11, 13–40, 42–114	
spf.ujumpx	spf.u_herex-spf.u_therex	m/s	Velocity jump, x component	Boundaries 1–11, 13–40, 42–114	
spf.ujumpy	spf.u_herey-spf.u_therey	m/s	Velocity jump, y component	Boundaries 1–11, 13–40, 42–114	
spf.ujumpz	spf.u_herez-spf.u_therez	m/s	Velocity jump, z component	Boundaries 1–11, 13–40, 42–114	
spf.contCoeffFace	down(spf.contCoeff)	kg/m^3	Help variable	Boundaries 1–11, 13–40, 42–114	
spf.rhoFace	down(spf.rho)	kg/m^3	Density face value	Boundaries 1–11, 13–40, 42–114	
spf.c_here	36*nojac(down(spf.mu+spf.muT)/down(1))*spf.meshVol/spf.meshVolInt	Pa·s/m	Intermediate variable	Boundaries 1–11, 13–40, 42–114	
spf.meshVol	meshvol_spatial	m^2		Boundaries 1–11, 13–40, 42–114	
spf.meshVolInt	down(meshvol_spatial)	m^3	Volume of interior mesh element	Boundaries 1–11, 13–40, 42–114	
spf.sigma_dg_ns	4*spf.c_here	Pa·s/m		Boundaries 1–11, 13–40, 42–114	
spf.umxTnFace	(spf.upwind_helpx*spf.nxmesh+spf.upwind_helpy*spf.nymesh+sp	m/s	Relative velocity on face	Boundaries 1–11, 13–40, 42–	

Name	Expression	Unit	Description	Selection	Details
	f.upwind_helpz*spf.nzmesh<0)*(spf.upwind_helpx*spf.nxmesh+spf.upwind_helpy*spf.nymesh+spf.upwind_helpz*spf.nzmesh)			114	
spf.upwind_ns	spf.rhoFace*spf.umxTnFace*spf.unJump*test(spf.un_here)/down(1)^2	W/m^2	Upwind term	Boundaries 1–11, 13–40, 42–114	
spf.upwindCont	spf.contCoeffFace*spf.unJump*test(p2)	$kg^2/(m^3\cdot s^3)$	Upwind term for continuity equation	Boundaries 1–11, 13–40, 42–114	
spf.pFace	p2	Pa	Pressure face value	Boundaries 1–11, 13–40, 42–114	
spf.consFlux	-spf.pFace*test(spf.un_here)	W/m^2	Conservative flux	Boundaries 1–11, 13–40, 42–114	+ operation
spf.d_w_plus	nojac(max(11.06,0.5*spf.mixLParam^0.25*sqrt(spf.k_nn)*down(spf.rho)/(down(spf.mu)*down(tremetric_spatial)^0.5)))	1	Wall lift-off in viscous units	Boundaries 1–11, 13–40, 42–114	
spf.uPlus	log(spf.d_w_plus)/spf.kappav+spf.B	1	Tangential velocity in viscous units	Boundaries 1–11, 13–40, 42–114	+ operation
spf.mixLParam	spf.C_mu	1	Intermediate variable	Boundaries 1–11, 13–40, 42–114	
spf.ep_w	spf.mixLParam*spf.k_nn^2*nojac(down(spf.rho))/(spf.kappav*spf.d_w_plus*nojac(down(spf.mu)))	m^2/s^3	Turbulent dissipation rate, (wall adjacent cells)	Boundaries 1–11, 13–40, 42–114	
spf.u_tau	nojac(max(spf.mixLParam^0.25*sqrt(spf.k_nn),sqrt(spf.u_tangx^2+spf.u_tangy^2+spf.u_tangz^2+eps)/spf.uPlus))	m/s	Friction velocity	Boundaries 1–11, 13–40, 42–114	
spf.u_tangx	u-spf.ubndx-spf.nxmesh*((u-	m/s	Velocity field, x component	Boundaries 1–11, 13–40, 42–	

Name	Expression	Unit	Description	Selection	Details
	spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-spf.ubndz)*spf.nzmesh)			114	
spf.u_tangy	v-spf.ubndy-spf.nymesh*((u-spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-spf.ubndz)*spf.nzmesh)	m/s	Velocity field, y component	Boundaries 1–11, 13–40, 42–114	
spf.u_tangz	w-spf.ubndz-spf.nzmesh*((u-spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-spf.ubndz)*spf.nzmesh)	m/s	Velocity field, z component	Boundaries 1–11, 13–40, 42–114	
spf.delta_w	spf.d_w_plus*down(spf.mu)/(down(spf.rho)*max(spf.u_tau,sqrt(eps)))	m	Wall lift-off	Boundaries 1–11, 13–40, 42–114	
spf.uStar	spf.u_tau	m/s	Friction velocity	Boundaries 1–11, 13–40, 42–114	
spf.Delta_wPlus	spf.d_w_plus	1	Wall resolution in viscous units	Boundaries 1–11, 13–40, 42–114	
spf.WRHeightExpr	-11.06+spf.d_w_plus	1	Wall resolution height expression	Boundaries 1–11, 13–40, 42–114	

Weak expressions

Weak expression	Integration order	Integration frame	Selection
spf.KStressn_avx*test(spf.u_herex)+spf.KStressn_avy*test(spf.u_herey)+spf.KStressn_avz*test(spf.u_herez)+spf.KStressTestn_avx*spf.ujumpx+spf.KStressTestn_avy*spf.ujumpy+spf.KStressTestn_avz*spf.ujumpz-spf.sigma_dg_ns*spf.unJump*test(spf.	2	Spatial	Boundaries 1–11, 13–40, 42–114

Weak expression	Integration order	Integration frame	Selection
un_here)+spf.upwind_ns+spf.upwindCont+spf.consFlux			
down(spf.rho)*spf.u_tau*(-spf.u_tangx*test(u)-spf.u_tangy*test(v)-spf.u_tangz*test(w))/spf.uPlus	2	Spatial	Boundaries 1–11, 13–40, 42–114

Constraints

Constraint	Constraint force	Shape function	Selection	Details
-ep2+spf.ep_w	test(-ep2)	Lagrange (Linear)	Boundaries 1–11, 13–40, 42–114	Elemental

2.4.6 Gravity 1

SELECTION

Geometric entity level	Entire model

EQUATIONS

$$\rho(\mathbf{u}\cdot\nabla)\mathbf{u} =$$
$$\nabla\cdot[-p2\mathbf{I}+\mathbf{K}]+\mathbf{F}+\rho\mathbf{g}$$

Acceleration of gravity

SETTINGS

Description	Value
Acceleration of gravity, x component	0
Acceleration of gravity, y component	0
Acceleration of gravity, z component	-g_const
Include buoyancy-induced turbulence	Off

Variables

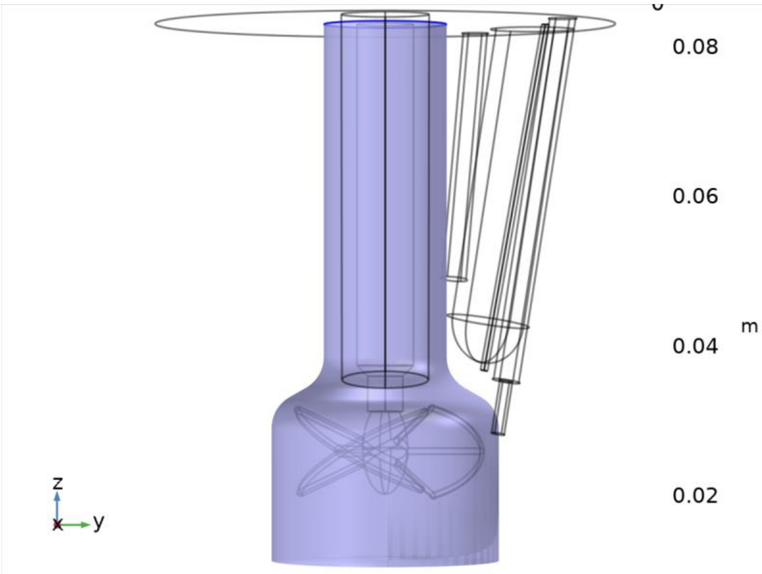
Name	Expression	Unit	Description	Selection	Details
spf.Fgtotx	spf.Fgx	N/m^3	Gravity force, x component	Domains 1–2	+ operation
spf.Fgtoty	spf.Fgy	N/m^3	Gravity force, y component	Domains 1–2	+ operation
spf.Fgtotz	spf.Fgz	N/m^3	Gravity force, z component	Domains 1–2	+ operation
spf.gx	0	m/s^2	Acceleration of gravity, x component	Global	
spf.gy	0	m/s^2	Acceleration of	Global	

Name	Expression	Unit	Description	Selection	Details
			gravity, y component		
spf.gz	-g_const	m/s²	Acceleration of gravity, z component	Global	
spf.Fgx	spf.rho*spf.gx	N/m³	Gravity force, x component	Domains 1–2	
spf.Fgy	spf.rho*spf.gy	N/m³	Gravity force, y component	Domains 1–2	
spf.Fgz	spf.rho*spf.gz	N/m³	Gravity force, z component	Domains 1–2	
spf.Pkbmph_mul	0	kg/(m³·s)		Domains 1–2	+ operation
spf.Pepbmph_mul	0	kg/(m³·s)		Domains 1–2	+ operation
spf.p_hydro	spf.rhoref*(spf.gx*(x-spf.rrefx)+spf.gy*(y-spf.rrefy)+spf.gz*(z-spf.rrefz))	Pa	Hydrostatic pressure	Domains 1–2	

Weak expressions

Weak expression	Integration order	Integration frame	Selection
spf.Fgx*test(u)+spf.Fgy*test(v)+spf.Fgz*test(w)	2	Spatial	Domains 1–2

2.4.7 Flow Continuity 1



Flow Continuity 1

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: All boundaries

EQUATIONS

$$\mathbf{u}_{\mathrm{src}} = \mathbf{u}_{\mathrm{dst}}\,,\;\; p2_{\mathrm{src}} = p2_{\mathrm{dst}}$$
$$k2_{\mathrm{src}} = k2_{\mathrm{dst}}\,,\;\; \epsilon_{\mathrm{src}} = \epsilon_{\mathrm{dst}}$$

Pair selection

SETTINGS

Description	Value
Pairs	Identity Boundary Pair 3a (ap3)

Variables

Name	Expression	Unit	Description	Selection	Details
spf.mu_here_ap3	down(spf.mu)	Pa·s	Dynamic viscosity	Boundary 12	
spf.mu_here_ap3	down(spf.mu)	Pa·s	Dynamic viscosity	Boundary 41	
spf.muT_here_ap3	spf.muT	Pa·s	Turbulent dynamic viscosity	Boundary 12	
spf.muT_here_ap3	spf.muT	Pa·s	Turbulent dynamic viscosity	Boundary 41	
spf.rho_here_ap3	down(spf.rho)	kg/m³	Density	Boundary 12	
spf.rho_here_ap3	down(spf.rho)	kg/m³	Density	Boundary 41	

Name	Expression	Unit	Description	Selection	Details
spf.rho_there_ap3	src2dst_ap3(spf.rho_here_ap3)	kg/m³	Density	Boundary 41	
spf.rho_there_ap3	dst2src_ap3(spf.rho_here_ap3)	kg/m³	Density	Boundary 12	
spf.contCoeff_here_ap3	down(spf.contCoeff)	kg/m³	Help variable	Boundary 12	
spf.contCoeff_here_ap3	down(spf.contCoeff)	kg/m³	Help variable	Boundary 41	
spf.meshVolInt_ap3	down(meshvol_spatial)	m³	Volume of interior mesh element	Boundary 12	
spf.meshVolInt_ap3	down(meshvol_spatial)	m³	Volume of interior mesh element	Boundary 41	
spf.meshVol_ap3	meshvol_spatial	m²		Boundary 12	
spf.meshVol_ap3	meshvol_spatial	m²		Boundary 41	
spf.u_here_ap3x	u	m/s	Intermediate variable, x component	Boundary 12	
spf.u_here_ap3y	v	m/s	Intermediate variable, y component	Boundary 12	
spf.u_here_ap3z	w	m/s	Intermediate variable, z component	Boundary 12	
spf.u_here_ap3x	u	m/s	Intermediate variable, x component	Boundary 41	
spf.u_here_ap3y	v	m/s	Intermediate variable, y component	Boundary 41	
spf.u_here_ap3z	w	m/s	Intermediate variable, z component	Boundary 41	
spf.u_there_ap3x	src2dst_ap3(u)	m/s	Intermediate variable, x component	Boundary 41	
spf.u_there_ap3y	src2dst_ap3(v)	m/s	Intermediate variable, y component	Boundary 41	
spf.u_there_ap3z	src2dst_ap3(w)	m/s	Intermediate variable, z	Boundary 41	

Name	Expression	Unit	Description	Selection	Details
			component		
spf.u_there_ap3x	dst2src_ap3(u)	m/s	Intermediate variable, x component	Boundary 12	
spf.u_there_ap3y	dst2src_ap3(v)	m/s	Intermediate variable, y component	Boundary 12	
spf.u_there_ap3z	dst2src_ap3(w)	m/s	Intermediate variable, z component	Boundary 12	
spf.p_here_ap3	p2	Pa	Pressure	Boundary 12	
spf.p_here_ap3	p2	Pa	Pressure	Boundary 41	
spf.KStressn_here_ap3x	spf.K_stress_tensorxx*spf.nxmesh+spf.K_stress_tensorxy*spf.nymesh+spf.K_stress_tensorxz*spf.nzmesh	N/m²	Average viscous stress, x component	Boundary 12	
spf.KStressn_here_ap3y	spf.K_stress_tensoryx*spf.nxmesh+spf.K_stress_tensoryy*spf.nymesh+spf.K_stress_tensoryz*spf.nzmesh	N/m²	Average viscous stress, y component	Boundary 12	
spf.KStressn_here_ap3z	spf.K_stress_tensorzx*spf.nxmesh+spf.K_stress_tensorzy*spf.nymesh+spf.K_stress_tensorzz*spf.nzmesh	N/m²	Average viscous stress, z component	Boundary 12	
spf.KStressn_here_ap3x	spf.K_stress_tensorxx*spf.nxmesh+spf.K_stress_tensorxy*spf.nymesh+spf.K_stress_tensorxz*spf.nzmesh	N/m²	Average viscous stress, x component	Boundary 41	
spf.KStressn_here_ap3y	spf.K_stress_tensoryx*spf.nxmesh+spf.K_stress_tensoryy*spf.nymesh+spf.K_stress_tensoryz*spf.nzmesh	N/m²	Average viscous stress, y component	Boundary 41	
spf.KStressn_here_ap3z	spf.K_stress_tensorzx*spf.nxmesh+spf.K_stress_tensorzy*spf.nymesh+spf.K_stress_tensorzz*spf.nzmesh	N/m²	Average viscous stress, z component	Boundary 41	
spf.KStressn_there	src2dst_ap3(spf.K_stress_tensorxx)*spf.nx	N/m²	Average viscous stress, x	Boundary 41	

Name	Expression	Unit	Description	Selection	Details
_ap3x	mesh+src2dst_ap3(spf.K_stress_tensorxy)*spf.nymesh+src2dst_ap3(spf.K_stress_tensorxz)*spf.nzmesh		component		
spf.KStressn_there_ap3y	src2dst_ap3(spf.K_stress_tensoryx)*spf.nxmesh+src2dst_ap3(spf.K_stress_tensoryy)*spf.nymesh+src2dst_ap3(spf.K_stress_tensoryz)*spf.nzmesh	N/m²	Average viscous stress, y component	Boundary 41	
spf.KStressn_there_ap3z	src2dst_ap3(spf.K_stress_tensorzx)*spf.nxmesh+src2dst_ap3(spf.K_stress_tensorzy)*spf.nymesh+src2dst_ap3(spf.K_stress_tensorzz)*spf.nzmesh	N/m²	Average viscous stress, z component	Boundary 41	
spf.KStressn_there_ap3x	dst2src_ap3(spf.K_stress_tensorxx)*spf.nxmesh+dst2src_ap3(spf.K_stress_tensorxy)*spf.nymesh+dst2src_ap3(spf.K_stress_tensorxz)*spf.nzmesh	N/m²	Average viscous stress, x component	Boundary 12	
spf.KStressn_there_ap3y	dst2src_ap3(spf.K_stress_tensoryx)*spf.nxmesh+dst2src_ap3(spf.K_stress_tensoryy)*spf.nymesh+dst2src_ap3(spf.K_stress_tensoryz)*spf.nzmesh	N/m²	Average viscous stress, y component	Boundary 12	
spf.KStressn_there_ap3z	dst2src_ap3(spf.K_stress_tensorzx)*spf.nxmesh+dst2src_ap3(spf.K_stress_tensorzy)*spf.nymesh+dst2src_ap3(spf.K_stress_tensorzz)*spf.nzmesh	N/m²	Average viscous stress, z component	Boundary 12	
spf.KStressn_av_ap3x	0.5*(spf.KStressn_here_ap3x+spf.KStressn_there_ap3x)	N/m²	Average viscous stress, x component	Boundary 12	
spf.KStressn_av_ap3y	0.5*(spf.KStressn_here_ap3y+spf.KStressn_	N/m²	Average viscous stress, y	Boundary 12	

Name	Expression	Unit	Description	Selection	Details
	there_ap3y)		component		
spf.KStressn_av_ap3z	0.5*(spf.KStressn_here_ap3z+spf.KStressn_there_ap3z)	N/m²	Average viscous stress, z component	Boundary 12	
spf.KStressn_av_ap3x	0.5*(spf.KStressn_here_ap3x+spf.KStressn_there_ap3x)	N/m²	Average viscous stress, x component	Boundary 41	
spf.KStressn_av_ap3y	0.5*(spf.KStressn_here_ap3y+spf.KStressn_there_ap3y)	N/m²	Average viscous stress, y component	Boundary 41	
spf.KStressn_av_ap3z	0.5*(spf.KStressn_here_ap3z+spf.KStressn_there_ap3z)	N/m²	Average viscous stress, z component	Boundary 41	
spf.ujump_ap3x	spf.u_here_ap3x-spf.u_there_ap3x	m/s	Velocity jump, x component	Boundary 12	
spf.ujump_ap3y	spf.u_here_ap3y-spf.u_there_ap3y	m/s	Velocity jump, y component	Boundary 12	
spf.ujump_ap3z	spf.u_here_ap3z-spf.u_there_ap3z	m/s	Velocity jump, z component	Boundary 12	
spf.ujump_ap3x	spf.u_here_ap3x-spf.u_there_ap3x	m/s	Velocity jump, x component	Boundary 41	
spf.ujump_ap3y	spf.u_here_ap3y-spf.u_there_ap3y	m/s	Velocity jump, y component	Boundary 41	
spf.ujump_ap3z	spf.u_here_ap3z-spf.u_there_ap3z	m/s	Velocity jump, z component	Boundary 41	
spf.c_here_ap3	36*nojac((spf.mu_here_ap3+spf.muT_here_ap3)/spf.epsilon_p)*spf.meshVol_ap3/spf.meshVolInt_ap3	Pa·s/m		Boundary 12	
spf.c_here_ap3	36*nojac((spf.mu_here_ap3+spf.muT_here_ap3)/spf.epsilon_p)*spf.meshVol_ap3/spf.meshVolInt_ap3	Pa·s/m		Boundary 41	
spf.sigma_dg_ns_ap3	spf.c_here_ap3+dst2src_ap3(spf.c_here_ap3)	Pa·s/m		Boundary 12	
spf.sigma_dg_ns_ap3	spf.c_here_ap3+src2dst_ap3(spf.c_here_ap3)	Pa·s/m		Boundary 41	
spf.rhoFace_ap3	0.5*(spf.rho_here_ap3	kg/m³	Density face	Boundary 12	

Name	Expression	Unit	Description	Selection	Details
	+spf.rho_there_ap3)		value		
spf.rhoFace_ap3	0.5*(spf.rho_here_ap3+spf.rho_there_ap3)	kg/m^3	Density face value	Boundary 41	
spf.rhoJump_ap3	spf.rho_here_ap3-spf.rho_there_ap3	kg/m^3	Density face value	Boundary 12	
spf.rhoJump_ap3	spf.rho_here_ap3-spf.rho_there_ap3	kg/m^3	Density face value	Boundary 41	
spf.contCoeffFace_ap3	0.5*(spf.contCoeff_here_ap3+dst2src_ap3(spf.contCoeff_here_ap3))	kg/m^3	Help variable	Boundary 12	
spf.contCoeffFace_ap3	0.5*(spf.contCoeff_here_ap3+src2dst_ap3(spf.contCoeff_here_ap3))	kg/m^3	Help variable	Boundary 41	
spf.umxTnFace_ap3	0.5*(spf.umxTn_here_ap3+spf.umxTn_there_ap3<0)*(spf.umxTn_here_ap3+spf.umxTn_there_ap3)	m/s	Relative velocity on face	Boundary 12	
spf.umxTnFace_ap3	0.5*(spf.umxTn_here_ap3+spf.umxTn_there_ap3<0)*(spf.umxTn_here_ap3+spf.umxTn_there_ap3)	m/s	Relative velocity on face	Boundary 41	
spf.umxTn_here_ap3	spf.upwind_helpx*spf.nxmesh+spf.upwind_helpy*spf.nymesh+spf.upwind_helpz*spf.nzmesh	m/s	Relative velocity on face	Boundary 12	
spf.umxTn_here_ap3	spf.upwind_helpx*spf.nxmesh+spf.upwind_helpy*spf.nymesh+spf.upwind_helpz*spf.nzmesh	m/s	Relative velocity on face	Boundary 41	
spf.umxTn_there_ap3	dst2src_ap3(spf.upwind_helpx)*spf.nxmesh+dst2src_ap3(spf.upwind_helpy)*spf.nymesh+dst2src_ap3(spf.upwind_helpz)*spf.nzmesh	m/s	Relative velocity on face	Boundary 12	
spf.umxTn_there_ap3	src2dst_ap3(spf.upwind_helpx)*spf.nxmes	m/s	Relative velocity on face	Boundary 41	

Name	Expression	Unit	Description	Selection	Details
	h+src2dst_ap3(spf.upwind_helpy)*spf.nymesh+src2dst_ap3(spf.upwind_helpz)*spf.nzmesh				
spf.upwind_ns_ap3	spf.rhoFace_ap3*spf.umxTnFace_ap3*(spf.ujump_ap3x*test(spf.u_here_ap3x)+spf.ujump_ap3y*test(spf.u_here_ap3y)+spf.ujump_ap3z*test(spf.u_here_ap3z))/spf.epsilon_p^2	W/m^2	Upwind term	Boundary 12	
spf.upwind_ns_ap3	spf.rhoFace_ap3*spf.umxTnFace_ap3*(spf.ujump_ap3x*test(spf.u_here_ap3x)+spf.ujump_ap3y*test(spf.u_here_ap3y)+spf.ujump_ap3z*test(spf.u_here_ap3z))/spf.epsilon_p^2	W/m^2	Upwind term	Boundary 41	
spf.upwindCont_ap3	0.5*spf.contCoeffFace_ap3*(spf.ujump_ap3x*spf.nxmesh+spf.ujump_ap3y*spf.nymesh+spf.ujump_ap3z*spf.nzmesh)*test(spf.p_here_ap3)	$kg^2/(m^3 \cdot s^3)$	Upwind term for continuity equation	Boundary 12	
spf.upwindCont_ap3	0.5*spf.contCoeffFace_ap3*(spf.ujump_ap3x*spf.nxmesh+spf.ujump_ap3y*spf.nymesh+spf.ujump_ap3z*spf.nzmesh)*test(spf.p_here_ap3)	$kg^2/(m^3 \cdot s^3)$	Upwind term for continuity equation	Boundary 41	
spf.p_there_ap3	dst2src_ap3(p2)	Pa	Pressure	Boundary 12	
spf.p_there_ap3	src2dst_ap3(p2)	Pa	Pressure	Boundary 41	
spf.pJump_ap3	spf.p_here_ap3-spf.p_there_ap3	Pa	Pressure jump	Boundary 12	
spf.pJump_ap3	spf.p_here_ap3-spf.p_there_ap3	Pa	Pressure jump	Boundary 41	
spf.pFace_ap3	0.5*(spf.p_here_ap3+	Pa	Pressure face	Boundary 12	

Name	Expression	Unit	Description	Selection	Details
	spf.p_there_ap3)		value		
spf.pFace_ap3	0.5*(spf.p_here_ap3+ spf.p_there_ap3)	Pa	Pressure face value	Boundary 41	
spf.consFlux_ap3	-spf.pFace_ap3*(test(spf.u_here_ap3x)*spf.nxmesh+test(spf.u_here_ap3y)*spf.nymesh+test(spf.u_here_ap3z)*spf.nzmesh)	W/m²	Conservative flux	Boundary 12	+ operation
spf.consFlux_ap3	-spf.pFace_ap3*(test(spf.u_here_ap3x)*spf.nxmesh+test(spf.u_here_ap3y)*spf.nymesh+test(spf.u_here_ap3z)*spf.nzmesh)	W/m²	Conservative flux	Boundary 41	+ operation
spf.kjump_ap3	k2-dst2src_ap3(k2)	m²/s²		Boundary 12	
spf.kjump_ap3	k2-src2dst_ap3(k2)	m²/s²		Boundary 41	
spf.Dk_ap3	spf.mu_here_ap3+spf.muT_here_ap3/spf.sigmak	Pa·s		Boundary 12	
spf.Dk_ap3	spf.mu_here_ap3+spf.muT_here_ap3/spf.sigmak	Pa·s		Boundary 41	
spf.gammak_here_ap3x	spf.Dk_ap3*k2x	W/m²		Boundary 12	
spf.gammak_here_ap3y	spf.Dk_ap3*k2y	W/m²		Boundary 12	
spf.gammak_here_ap3z	spf.Dk_ap3*k2z	W/m²		Boundary 12	
spf.gammak_here_ap3x	spf.Dk_ap3*k2x	W/m²		Boundary 41	
spf.gammak_here_ap3y	spf.Dk_ap3*k2y	W/m²		Boundary 41	
spf.gammak_here_ap3z	spf.Dk_ap3*k2z	W/m²		Boundary 41	
spf.gammak_there_ap3x	src2dst_ap3(spf.Dk_ap3*k2x)	W/m²		Boundary 41	
spf.gammak_there_ap3y	src2dst_ap3(spf.Dk_ap3*k2y)	W/m²		Boundary 41	
spf.gammak_there	src2dst_ap3(spf.Dk_a	W/m²		Boundary 41	

Name	Expression	Unit	Description	Selection	Details
_ap3z	p3*k2z)				
spf.gammak_there_ap3x	dst2src_ap3(spf.Dk_ap3*k2x)	W/m²		Boundary 12	
spf.gammak_there_ap3y	dst2src_ap3(spf.Dk_ap3*k2y)	W/m²		Boundary 12	
spf.gammak_there_ap3z	dst2src_ap3(spf.Dk_ap3*k2z)	W/m²		Boundary 12	
spf.gammakn_av_ap3	0.5*((spf.gammak_here_ap3x+spf.gammak_there_ap3x)*spf.nxmesh+(spf.gammak_here_ap3y+spf.gammak_there_ap3y)*spf.nymesh+(spf.gammak_here_ap3z+spf.gammak_there_ap3z)*spf.nzmesh)*test(k2)	kg·m²/s⁵		Boundary 12	
spf.gammakn_av_ap3	0.5*((spf.gammak_here_ap3x+spf.gammak_there_ap3x)*spf.nxmesh+(spf.gammak_here_ap3y+spf.gammak_there_ap3y)*spf.nymesh+(spf.gammak_here_ap3z+spf.gammak_there_ap3z)*spf.nzmesh)*test(k2)	kg·m²/s⁵		Boundary 41	
spf.gammakn_av_test_ap3	0.5*spf.Dk_ap3*(test(k2x)*spf.nxmesh+test(k2y)*spf.nymesh+test(k2z)*spf.nzmesh)*spf.kjump_ap3	kg·m²/s⁵		Boundary 12	
spf.gammakn_av_test_ap3	0.5*spf.Dk_ap3*(test(k2x)*spf.nxmesh+test(k2y)*spf.nymesh+test(k2z)*spf.nzmesh)*spf.kjump_ap3	kg·m²/s⁵		Boundary 41	
spf.c_here_k_ap3	18*nojac(spf.Dk_ap3)*spf.meshVol_ap3/spf.meshVolInt_ap3	Pa·s/m		Boundary 12	
spf.c_here_k_ap3	18*nojac(spf.Dk_ap3)*spf.meshVol_ap3/spf.meshVolInt_ap3	Pa·s/m		Boundary 41	
spf.sigma_dg_k_ap	spf.c_here_k_ap3+dst	Pa·s/m		Boundary 12	

Name	Expression	Unit	Description	Selection	Details
3	2src_ap3(spf.c_here_k_ap3)				
spf.sigma_dg_k_ap3	spf.c_here_k_ap3+src2dst_ap3(spf.c_here_k_ap3)	Pa·s/m		Boundary 41	
spf.upwind_k_ap3	spf.rhoFace_ap3*spf.umxTnFace_ap3*spf.kjump_ap3*test(k2)	kg·m²/s⁵	Upwind term	Boundary 12	
spf.upwind_k_ap3	spf.rhoFace_ap3*spf.umxTnFace_ap3*spf.kjump_ap3*test(k2)	kg·m²/s⁵	Upwind term	Boundary 41	
spf.epjump_ap3	ep2-dst2src_ap3(ep2)	m²/s²		Boundary 12	
spf.epjump_ap3	ep2-src2dst_ap3(ep2)	m²/s²		Boundary 41	
spf.Dep_ap3	spf.mu_here_ap3+spf.muT_here_ap3/spf.sigmaeps	Pa·s		Boundary 12	
spf.Dep_ap3	spf.mu_here_ap3+spf.muT_here_ap3/spf.sigmaeps	Pa·s		Boundary 41	
spf.gammaep_here_ap3x	spf.Dep_ap3*ep2x	kg/s⁴		Boundary 12	
spf.gammaep_here_ap3y	spf.Dep_ap3*ep2y	kg/s⁴		Boundary 12	
spf.gammaep_here_ap3z	spf.Dep_ap3*ep2z	kg/s⁴		Boundary 12	
spf.gammaep_here_ap3x	spf.Dep_ap3*ep2x	kg/s⁴		Boundary 41	
spf.gammaep_here_ap3y	spf.Dep_ap3*ep2y	kg/s⁴		Boundary 41	
spf.gammaep_here_ap3z	spf.Dep_ap3*ep2z	kg/s⁴		Boundary 41	
spf.gammaep_there_ap3x	src2dst_ap3(spf.Dep_ap3*ep2x)	kg/s⁴		Boundary 41	
spf.gammaep_there_ap3y	src2dst_ap3(spf.Dep_ap3*ep2y)	kg/s⁴		Boundary 41	
spf.gammaep_there_ap3z	src2dst_ap3(spf.Dep_ap3*ep2z)	kg/s⁴		Boundary 41	
spf.gammaep_there_ap3x	dst2src_ap3(spf.Dep_ap3*ep2x)	kg/s⁴		Boundary 12	
spf.gammaep_there_ap3y	dst2src_ap3(spf.Dep_ap3*ep2y)	kg/s⁴		Boundary 12	

Name	Expression	Unit	Description	Selection	Details
spf.gammaep_there_ap3z	dst2src_ap3(spf.Dep_ap3*ep2z)	kg/s⁴		Boundary 12	
spf.gammaepn_av_ap3	0.5*((spf.gammaep_here_ap3x+spf.gammaep_there_ap3x)*spf.nxmesh+(spf.gammaep_here_ap3y+spf.gammaep_there_ap3y)*spf.nymesh+(spf.gammaep_here_ap3z+spf.gammaep_there_ap3z)*spf.nzmesh)*test(ep2)	kg·m²/s⁷		Boundary 12	
spf.gammaepn_av_ap3	0.5*((spf.gammaep_here_ap3x+spf.gammaep_there_ap3x)*spf.nxmesh+(spf.gammaep_here_ap3y+spf.gammaep_there_ap3y)*spf.nymesh+(spf.gammaep_here_ap3z+spf.gammaep_there_ap3z)*spf.nzmesh)*test(ep2)	kg·m²/s⁷		Boundary 41	
spf.gammaepn_av_test_ap3	0.5*spf.Dep_ap3*(test(ep2x)*spf.nxmesh+test(ep2y)*spf.nymesh+test(ep2z)*spf.nzmesh)*spf.epjump_ap3	kg·m²/s⁶		Boundary 12	
spf.gammaepn_av_test_ap3	0.5*spf.Dep_ap3*(test(ep2x)*spf.nxmesh+test(ep2y)*spf.nymesh+test(ep2z)*spf.nzmesh)*spf.epjump_ap3	kg·m²/s⁶		Boundary 41	
spf.c_here_ep_ap3	18*nojac(spf.Dep_ap3)*spf.meshVol_ap3/spf.meshVolInt_ap3	Pa·s/m		Boundary 12	
spf.c_here_ep_ap3	18*nojac(spf.Dep_ap3)*spf.meshVol_ap3/spf.meshVolInt_ap3	Pa·s/m		Boundary 41	
spf.sigma_dg_ep_ap3	spf.c_here_ep_ap3+dst2src_ap3(spf.c_here_ep_ap3)	Pa·s/m		Boundary 12	
spf.sigma_dg_ep_ap3	spf.c_here_ep_ap3+src2dst_ap3(spf.c_here_	Pa·s/m		Boundary 41	

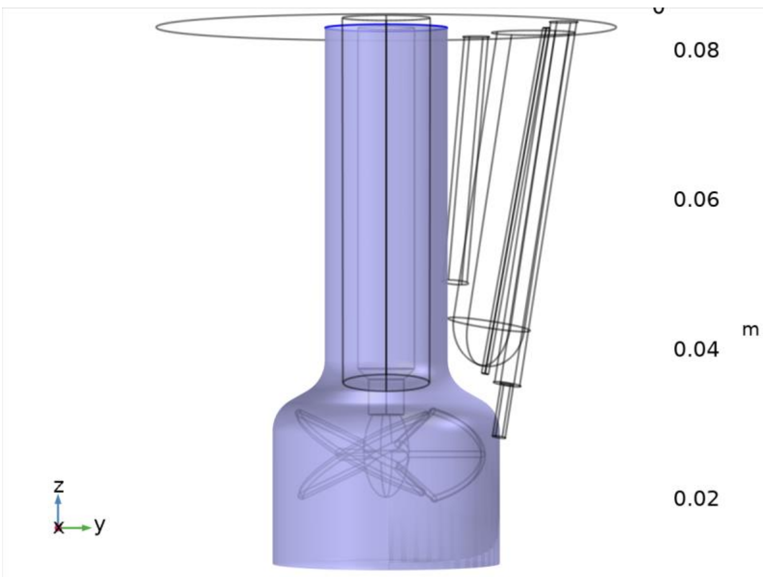
Name	Expression	Unit	Description	Selection	Details
	ep_ap3)				
spf.upwind_ep_ap3	spf.rhoFace_ap3*spf.umxTnFace_ap3*spf.epjump_ap3*test(ep2)	kg·m²/s⁶	Upwind term	Boundary 12	
spf.upwind_ep_ap3	spf.rhoFace_ap3*spf.umxTnFace_ap3*spf.epjump_ap3*test(ep2)	kg·m²/s⁶	Upwind term	Boundary 41	

Weak expressions

Weak expression	Integration order	Integration frame	Selection
if(incontact_ap3,spf.KStressn_av_ap3x*test(spf.u_here_ap3x)+spf.KStressn_av_ap3y*test(spf.u_here_ap3y)+spf.KStressn_av_ap3z*test(spf.u_here_ap3z),0)	6	Spatial	Boundary 12
if(incontact_ap3,0.5*((spf.K_stress_tensor_testxx*spf.nxmesh+spf.K_stress_tensor_testxy*spf.nymesh+spf.K_stress_tensor_testxz*spf.nzmesh)*spf.ujump_ap3x+(spf.K_stress_tensor_testyx*spf.nxmesh+spf.K_stress_tensor_testyy*spf.nymesh+spf.K_stress_tensor_testyz*spf.nzmesh)*spf.ujump_ap3y+(spf.K_stress_tensor_testzx*spf.nxmesh+spf.K_stress_tensor_testzy*spf.nymesh+spf.K_stress_tensor_testzz*spf.nzmesh)*spf.ujump_ap3z),0)	6	Spatial	Boundary 12
if(incontact_ap3,spf.sigma_dg_ns_ap3*(-spf.ujump_ap3x*test(spf.u_here_ap3x)-spf.ujump_ap3y*test(spf.u_here_ap3y)-spf.ujump_ap3z*test(spf.u_here_ap3z)),0)	6	Spatial	Boundary 12
if(incontact_ap3,spf.upwind_ns_ap3+spf.upwindCont_ap3+spf.consFlux_ap3,0)	6	Spatial	Boundary 12
if(incontact_ap3,spf.KStressn_av_ap3x*test(spf.u_here_ap3x)+spf.KStressn_av_ap3y*test(spf.u_here_ap3y)+spf.KStressn_av_ap3z*test(spf.u_here_ap3z),0)	6	Spatial	Boundary 41
if(incontact_ap3,0.5*((spf.K_stress_te	6	Spatial	Boundary 41

Weak expression	Integration order	Integration frame	Selection
nsor_testxx*spf.nxmesh+spf.K_stress_tensor_testxy*spf.nymesh+spf.K_stress_tensor_testxz*spf.nzmesh)*spf.ujump_ap3x+(spf.K_stress_tensor_testyx*spf.nxmesh+spf.K_stress_tensor_testyy*spf.nymesh+spf.K_stress_tensor_testyz*spf.nzmesh)*spf.ujump_ap3y+(spf.K_stress_tensor_testzx*spf.nxmesh+spf.K_stress_tensor_testzy*spf.nymesh+spf.K_stress_tensor_testzz*spf.nzmesh)*spf.ujump_ap3z),0)			
if(incontact_ap3,spf.sigma_dg_ns_ap3*(-spf.ujump_ap3x*test(spf.u_here_ap3x)-spf.ujump_ap3y*test(spf.u_here_ap3y)-spf.ujump_ap3z*test(spf.u_here_ap3z)),0)	6	Spatial	Boundary 41
if(incontact_ap3,spf.upwind_ns_ap3+spf.upwindCont_ap3+spf.consFlux_ap3,0)	6	Spatial	Boundary 41
if(incontact_ap3,spf.gammakn_av_ap3+spf.gammakn_av_test_ap3-spf.sigma_dg_k_ap3*spf.kjump_ap3*test(k2)+spf.upwind_k_ap3,0)	6	Spatial	Boundary 12
if(incontact_ap3,spf.gammakn_av_ap3+spf.gammakn_av_test_ap3-spf.sigma_dg_k_ap3*spf.kjump_ap3*test(k2)+spf.upwind_k_ap3,0)	6	Spatial	Boundary 41
if(incontact_ap3,spf.gammaepn_av_ap3+spf.gammaepn_av_test_ap3-spf.sigma_dg_ep_ap3*spf.epjump_ap3*test(ep2)+spf.upwind_ep_ap3,0)	6	Spatial	Boundary 12
if(incontact_ap3,spf.gammaepn_av_ap3+spf.gammaepn_av_test_ap3-spf.sigma_dg_ep_ap3*spf.epjump_ap3*test(ep2)+spf.upwind_ep_ap3,0)	6	Spatial	Boundary 41

Wall 1



Wall 1

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: All boundaries

EQUATIONS

$$\mathbf{u}\cdot\mathbf{n} = \mathbf{u}_{\mathrm{tr}}\cdot\mathbf{n}$$

$$\mathbf{K}\mathbf{n} = -\rho\frac{u_\tau}{u^+}\mathbf{u}_{\mathrm{rel,\ tang}}$$

$$\mathbf{u}_{\mathrm{rel}} = \mathbf{u} - \mathbf{u}_{\mathrm{tr}},\ \ \mathbf{u}_{\mathrm{rel,\ tang}} = \mathbf{u}_{\mathrm{rel}} - (\mathbf{u}_{\mathrm{rel}}\cdot\mathbf{n})\mathbf{n}$$

$$\nabla k2\cdot\mathbf{n} = 0,\ \ \epsilon = \rho\frac{C_\mu k2^2}{\kappa_v\delta_w^+\mu}$$

Boundary condition

SETTINGS

Description	Value
Wall condition	No slip
Apply wall roughness	Off

Wall movement

SETTINGS

Description	Value
Translational velocity	Automatic from frame
Sliding wall	Off

Variables

Name	Expression	Unit	Description	Selection	Details
spf.hasWF	if(!incontact_ap3,1,0)		Help variable	Boundary 41	
spf.hasWF	if(!incontact_ap3,1,0)		Help variable	Boundary 12	
spf.k_nn	if(!incontact_ap3,max(k2,0),0)	m^2/s^2	Regularized turbulent kinetic energy	Boundary 41	
spf.k_nn	if(!incontact_ap3,max(k2,0),0)	m^2/s^2	Regularized turbulent kinetic energy	Boundary 12	
spf.ubndx	if(!incontact_ap3,spf.utrx+spf.usx,0)	m/s	Velocity at boundary, x component	Boundary 41	
spf.ubndy	if(!incontact_ap3,spf.utry+spf.usy,0)	m/s	Velocity at boundary, y component	Boundary 41	
spf.ubndz	if(!incontact_ap3,spf.utrz+spf.usz,0)	m/s	Velocity at boundary, z component	Boundary 41	
spf.ubndx	if(!incontact_ap3,spf.utrx+spf.usx,0)	m/s	Velocity at boundary, x component	Boundary 12	
spf.ubndy	if(!incontact_ap3,spf.utry+spf.usy,0)	m/s	Velocity at boundary, y component	Boundary 12	
spf.ubndz	if(!incontact_ap3,spf.utrz+spf.usz,0)	m/s	Velocity at boundary, z component	Boundary 12	
spf.usx	0	m/s	Velocity of sliding wall, x component	Boundary 41	
spf.usy	0	m/s	Velocity of sliding wall, y component	Boundary 41	
spf.usz	0	m/s	Velocity of sliding wall, z component	Boundary 41	
spf.usx	0	m/s	Velocity of sliding wall, x component	Boundary 12	
spf.usy	0	m/s	Velocity of sliding wall, y component	Boundary 12	

Name	Expression	Unit	Description	Selection	Details
spf.usz	0	m/s	Velocity of sliding wall, z component	Boundary 12	
spf.utrx	if(!incontact_ap3,d(x,TIME),0)	m/s	Velocity of moving wall, x component	Boundary 41	
spf.utry	if(!incontact_ap3,d(y,TIME),0)	m/s	Velocity of moving wall, y component	Boundary 41	
spf.utrz	if(!incontact_ap3,d(z,TIME),0)	m/s	Velocity of moving wall, z component	Boundary 41	
spf.utrx	0	m/s	Velocity of moving wall, x component	Boundary 12	
spf.utry	0	m/s	Velocity of moving wall, y component	Boundary 12	
spf.utrz	0	m/s	Velocity of moving wall, z component	Boundary 12	
spf.uLeakagex	0	m/s	Leakage velocity, x component	Boundary 41	+ operation
spf.uLeakagey	0	m/s	Leakage velocity, y component	Boundary 41	+ operation
spf.uLeakagez	0	m/s	Leakage velocity, z component	Boundary 41	+ operation
spf.uLeakagex	0	m/s	Leakage velocity, x component	Boundary 12	+ operation
spf.uLeakagey	0	m/s	Leakage velocity, y component	Boundary 12	+ operation
spf.uLeakagez	0	m/s	Leakage velocity, z component	Boundary 12	+ operation
spf.noSlipWall	if(!incontact_ap3,1,0)	1	Help variable	Boundary 41	
spf.noSlipWall	if(!incontact_ap3,1,0)	1	Help variable	Boundary 12	
spf.un_here	if(!incontact_ap3,u*nojac(spf.nxmesh)+v*nojac(spf.nymesh)+w*nojac(spf.nzmesh),0)	m/s	Intermediate variable	Boundary 41	
spf.un_here	if(!incontact_ap3,u*nojac(spf.nxmesh)+v*nojac(spf.nymesh)+w*noja	m/s	Intermediate variable	Boundary 12	

Name	Expression	Unit	Description	Selection	Details
	c(spf.nzmesh),0)				
spf.u_herex	if(!incontact_ap3,spf.un_here*nojac(spf.nxmesh),0)	m/s	Intermediate variable, x component	Boundary 41	
spf.u_herey	if(!incontact_ap3,spf.un_here*nojac(spf.nymesh),0)	m/s	Intermediate variable, y component	Boundary 41	
spf.u_herez	if(!incontact_ap3,spf.un_here*nojac(spf.nzmesh),0)	m/s	Intermediate variable, z component	Boundary 41	
spf.u_herex	if(!incontact_ap3,spf.un_here*nojac(spf.nxmesh),0)	m/s	Intermediate variable, x component	Boundary 12	
spf.u_herey	if(!incontact_ap3,spf.un_here*nojac(spf.nymesh),0)	m/s	Intermediate variable, y component	Boundary 12	
spf.u_herez	if(!incontact_ap3,spf.un_here*nojac(spf.nzmesh),0)	m/s	Intermediate variable, z component	Boundary 12	
spf.un_there	if(!incontact_ap3,(spf.ubndx+spf.uLeakagex)*nojac(spf.nxmesh)+(spf.ubndy+spf.uLeakagey)*nojac(spf.nymesh)+(spf.ubndz+spf.uLeakagez)*nojac(spf.nzmesh),0)	m/s	Intermediate variable	Boundary 41	
spf.un_there	if(!incontact_ap3,(spf.ubndx+spf.uLeakagex)*nojac(spf.nxmesh)+(spf.ubndy+spf.uLeakagey)*nojac(spf.nymesh)+(spf.ubndz+spf.uLeakagez)*nojac(spf.nzmesh),0)	m/s	Intermediate variable	Boundary 12	
spf.u_therex	if(!incontact_ap3,spf.un_there*nojac(spf.nxmesh),0)	m/s	Intermediate variable, x component	Boundary 41	
spf.u_therey	if(!incontact_ap3,spf.un_there*nojac(spf.nymesh),0)	m/s	Intermediate variable, y component	Boundary 41	
spf.u_therez	if(!incontact_ap3,spf.un_there*nojac(spf.nzmesh),0)	m/s	Intermediate variable, z component	Boundary 41	

Name	Expression	Unit	Description	Selection	Details
spf.u_therex	if(!incontact_ap3,spf.un_there*nojac(spf.nxmesh),0)	m/s	Intermediate variable, x component	Boundary 12	
spf.u_therey	if(!incontact_ap3,spf.un_there*nojac(spf.nymesh),0)	m/s	Intermediate variable, y component	Boundary 12	
spf.u_therez	if(!incontact_ap3,spf.un_there*nojac(spf.nzmesh),0)	m/s	Intermediate variable, z component	Boundary 12	
spf.unJump	if(!incontact_ap3,spf.un_here-spf.un_there,0)	m/s	Jump in normal velocity	Boundary 41	
spf.unJump	if(!incontact_ap3,spf.un_here-spf.un_there,0)	m/s	Jump in normal velocity	Boundary 12	
spf.KStressn_avx	if(!incontact_ap3,spf.K_stress_tensorxx*spf.nxmesh+spf.K_stress_tensorxy*spf.nymesh+spf.K_stress_tensorxz*spf.nzmesh,0)	N/m²	Average viscous stress, x component	Boundary 41	
spf.KStressn_avy	if(!incontact_ap3,spf.K_stress_tensoryx*spf.nxmesh+spf.K_stress_tensoryy*spf.nymesh+spf.K_stress_tensoryz*spf.nzmesh,0)	N/m²	Average viscous stress, y component	Boundary 41	
spf.KStressn_avz	if(!incontact_ap3,spf.K_stress_tensorzx*spf.nxmesh+spf.K_stress_tensorzy*spf.nymesh+spf.K_stress_tensorzz*spf.nzmesh,0)	N/m²	Average viscous stress, z component	Boundary 41	
spf.KStressn_avx	if(!incontact_ap3,spf.K_stress_tensorxx*spf.nxmesh+spf.K_stress_tensorxy*spf.nymesh+spf.K_stress_tensorxz*spf.nzmesh,0)	N/m²	Average viscous stress, x component	Boundary 12	
spf.KStressn_avy	if(!incontact_ap3,spf.K_stress_tensoryx*spf.nxmesh+spf.K_stress_tensoryy*spf.nymesh+spf.K_stress_tensoryz*spf.nzmesh,0)	N/m²	Average viscous stress, y component	Boundary 12	
spf.KStressn_avz	if(!incontact_ap3,spf.K	N/m²	Average viscous	Boundary 12	

Name	Expression	Unit	Description	Selection	Details
	_stress_tensorzx*spf.nxmesh+spf.K_stress_tensorzy*spf.nymesh+spf.K_stress_tensorzz*spf.nzmesh,0)		stress, z component		
spf.KStressTestn_avx	if(!incontact_ap3,spf.K_stress_tensor_testxx*spf.nxmesh+spf.K_stress_tensor_testxy*spf.nymesh+spf.K_stress_tensor_testxz*spf.nzmesh,0)	N/m²	Average viscous stress, x component	Boundary 41	
spf.KStressTestn_avy	if(!incontact_ap3,spf.K_stress_tensor_testyx*spf.nxmesh+spf.K_stress_tensor_testyy*spf.nymesh+spf.K_stress_tensor_testyz*spf.nzmesh,0)	N/m²	Average viscous stress, y component	Boundary 41	
spf.KStressTestn_avz	if(!incontact_ap3,spf.K_stress_tensor_testzx*spf.nxmesh+spf.K_stress_tensor_testzy*spf.nymesh+spf.K_stress_tensor_testzz*spf.nzmesh,0)	N/m²	Average viscous stress, z component	Boundary 41	
spf.KStressTestn_avx	if(!incontact_ap3,spf.K_stress_tensor_testxx*spf.nxmesh+spf.K_stress_tensor_testxy*spf.nymesh+spf.K_stress_tensor_testxz*spf.nzmesh,0)	N/m²	Average viscous stress, x component	Boundary 12	
spf.KStressTestn_avy	if(!incontact_ap3,spf.K_stress_tensor_testyx*spf.nxmesh+spf.K_stress_tensor_testyy*spf.nymesh+spf.K_stress_tensor_testyz*spf.nzmesh,0)	N/m²	Average viscous stress, y component	Boundary 12	
spf.KStressTestn_avz	if(!incontact_ap3,spf.K_stress_tensor_testzx*spf.nxmesh+spf.K_stress_tensor_testzy*spf.nymesh+spf.K_stress_tensor_testzz*spf.nzmesh,	N/m²	Average viscous stress, z component	Boundary 12	

Name	Expression	Unit	Description	Selection	Details
	0)				
spf.ujumpx	if(!incontact_ap3,spf.u_herex-spf.u_therex,0)	m/s	Velocity jump, x component	Boundary 41	
spf.ujumpy	if(!incontact_ap3,spf.u_herey-spf.u_therey,0)	m/s	Velocity jump, y component	Boundary 41	
spf.ujumpz	if(!incontact_ap3,spf.u_herez-spf.u_therez,0)	m/s	Velocity jump, z component	Boundary 41	
spf.ujumpx	if(!incontact_ap3,spf.u_herex-spf.u_therex,0)	m/s	Velocity jump, x component	Boundary 12	
spf.ujumpy	if(!incontact_ap3,spf.u_herey-spf.u_therey,0)	m/s	Velocity jump, y component	Boundary 12	
spf.ujumpz	if(!incontact_ap3,spf.u_herez-spf.u_therez,0)	m/s	Velocity jump, z component	Boundary 12	
spf.contCoeffFace	if(!incontact_ap3,down(spf.contCoeff),0)	kg/m³	Help variable	Boundary 41	
spf.contCoeffFace	if(!incontact_ap3,down(spf.contCoeff),0)	kg/m³	Help variable	Boundary 12	
spf.rhoFace	if(!incontact_ap3,down(spf.rho),0)	kg/m³	Density face value	Boundary 41	
spf.rhoFace	if(!incontact_ap3,down(spf.rho),0)	kg/m³	Density face value	Boundary 12	
spf.c_here	if(!incontact_ap3,36*nojac(down(spf.mu+spf.muT)/down(1))*spf.meshVol/spf.meshVolInt,0)	Pa·s/m	Intermediate variable	Boundary 41	
spf.c_here	if(!incontact_ap3,36*nojac(down(spf.mu+spf.muT)/down(1))*spf.meshVol/spf.meshVolInt,0)	Pa·s/m	Intermediate variable	Boundary 12	
spf.meshVol	if(!incontact_ap3,meshvol_spatial,if(!incontact_ap3,meshvol,0))	m²		Boundary 41	
spf.meshVol	if(!incontact_ap3,meshvol_spatial,if(!incontact_ap3,meshvol,0))	m²		Boundary 12	
spf.meshVolInt	if(!incontact_ap3,down(meshvol_spatial),if(!incontact_ap3,down(meshvol),0))	m³	Volume of interior mesh element	Boundary 41	
spf.meshVolInt	if(!incontact_ap3,down	m³	Volume of	Boundary 12	

Name	Expression	Unit	Description	Selection	Details
	(meshvol_spatial),if(!incontact_ap3,down(meshvol),0))		interior mesh element		
spf.sigma_dg_ns	if(!incontact_ap3,4*spf.c_here,0)	Pa·s/m		Boundary 41	
spf.sigma_dg_ns	if(!incontact_ap3,4*spf.c_here,0)	Pa·s/m		Boundary 12	
spf.umxTnFace	if(!incontact_ap3,(spf.upwind_helpx*spf.nxmesh+spf.upwind_helpy*spf.nymesh+spf.upwind_helpz*spf.nzmesh<0)*(spf.upwind_helpx*spf.nxmesh+spf.upwind_helpy*spf.nymesh+spf.upwind_helpz*spf.nzmesh),0)	m/s	Relative velocity on face	Boundary 41	
spf.umxTnFace	if(!incontact_ap3,(spf.upwind_helpx*spf.nxmesh+spf.upwind_helpy*spf.nymesh+spf.upwind_helpz*spf.nzmesh<0)*(spf.upwind_helpx*spf.nxmesh+spf.upwind_helpy*spf.nymesh+spf.upwind_helpz*spf.nzmesh),0)	m/s	Relative velocity on face	Boundary 12	
spf.upwind_ns	if(!incontact_ap3,spf.rhoFace*spf.umxTnFace*spf.unJump*test(spf.un_here)/down(1)^2,0)	W/m^2	Upwind term	Boundary 41	
spf.upwind_ns	if(!incontact_ap3,spf.rhoFace*spf.umxTnFace*spf.unJump*test(spf.un_here)/down(1)^2,0)	W/m^2	Upwind term	Boundary 12	
spf.upwindCont	if(!incontact_ap3,spf.contCoeffFace*spf.unJump*test(p2),0)	$kg^2/(m^3 \cdot s^3)$	Upwind term for continuity equation	Boundary 41	
spf.upwindCont	if(!incontact_ap3,spf.contCoeffFace*spf.unJump*test(p2),0)	$kg^2/(m^3 \cdot s^3)$	Upwind term for continuity equation	Boundary 12	
spf.pFace	if(!incontact_ap3,p2,0)	Pa	Pressure face value	Boundary 41	
spf.pFace	if(!incontact_ap3,p2,0)	Pa	Pressure face	Boundary 12	

Name	Expression	Unit	Description	Selection	Details
			value		
spf.consFlux	if(!incontact_ap3,-spf.pFace*test(spf.un_here),0)	W/m²	Conservative flux	Boundary 41	+ operation
spf.consFlux	if(!incontact_ap3,-spf.pFace*test(spf.un_here),0)	W/m²	Conservative flux	Boundary 12	+ operation
spf.d_w_plus	if(!incontact_ap3,nojac(max(11.06,0.5*spf.mixLParam^0.25*sqrt(spf.k_nn)*down(spf.rho)/(down(spf.mu)*down(tremetric_spatial)^0.5))),0)	1	Wall lift-off in viscous units	Boundary 41	
spf.d_w_plus	if(!incontact_ap3,nojac(max(11.06,0.5*spf.mixLParam^0.25*sqrt(spf.k_nn)*down(spf.rho)/(down(spf.mu)*down(tremetric_spatial)^0.5))),0)	1	Wall lift-off in viscous units	Boundary 12	
spf.uPlus	if(!incontact_ap3,log(spf.d_w_plus)/spf.kappav+spf.B,0)	1	Tangential velocity in viscous units	Boundary 41	+ operation
spf.uPlus	if(!incontact_ap3,log(spf.d_w_plus)/spf.kappav+spf.B,0)	1	Tangential velocity in viscous units	Boundary 12	+ operation
spf.mixLParam	if(!incontact_ap3,spf.C_mu,0)	1	Intermediate variable	Boundary 41	
spf.mixLParam	if(!incontact_ap3,spf.C_mu,0)	1	Intermediate variable	Boundary 12	
spf.ep_w	if(!incontact_ap3,spf.mixLParam*spf.k_nn^2*nojac(down(spf.rho))/(spf.kappav*spf.d_w_plus*nojac(down(spf.mu))),0)	m²/s³	Turbulent dissipation rate, (wall adjacent cells)	Boundary 41	
spf.ep_w	if(!incontact_ap3,spf.mixLParam*spf.k_nn^2*nojac(down(spf.rho))/(spf.kappav*spf.d_w_plus*nojac(down(spf.mu))),0)	m²/s³	Turbulent dissipation rate, (wall adjacent cells)	Boundary 12	
spf.u_tau	if(!incontact_ap3,nojac	m/s	Friction velocity	Boundary 41	

Name	Expression	Unit	Description	Selection	Details
	(max(spf.mixLParam^0.25*sqrt(spf.k_nn),sqrt(spf.u_tangx^2+spf.u_tangy^2+spf.u_tangz^2+eps)/spf.uPlus)),0)				
spf.u_tau	if(!incontact_ap3,nojac(max(spf.mixLParam^0.25*sqrt(spf.k_nn),sqrt(spf.u_tangx^2+spf.u_tangy^2+spf.u_tangz^2+eps)/spf.uPlus)),0)	m/s	Friction velocity	Boundary 12	
spf.u_tangx	if(!incontact_ap3,u-spf.ubndx-spf.nxmesh*((u-spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-spf.ubndz)*spf.nzmesh),0)	m/s	Velocity field, x component	Boundary 41	
spf.u_tangy	if(!incontact_ap3,v-spf.ubndy-spf.nymesh*((u-spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-spf.ubndz)*spf.nzmesh),0)	m/s	Velocity field, y component	Boundary 41	
spf.u_tangz	if(!incontact_ap3,w-spf.ubndz-spf.nzmesh*((u-spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-spf.ubndz)*spf.nzmesh),0)	m/s	Velocity field, z component	Boundary 41	
spf.u_tangx	if(!incontact_ap3,u-spf.ubndx-spf.nxmesh*((u-spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-spf.ubndz)*spf.nzmesh	m/s	Velocity field, x component	Boundary 12	

Name	Expression	Unit	Description	Selection	Details
	),0)				
spf.u_tangy	if(!incontact_ap3,v-spf.ubndy-spf.nymesh*((u-spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-spf.ubndz)*spf.nzmesh),0)	m/s	Velocity field, y component	Boundary 12	
spf.u_tangz	if(!incontact_ap3,w-spf.ubndz-spf.nzmesh*((u-spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-spf.ubndz)*spf.nzmesh),0)	m/s	Velocity field, z component	Boundary 12	
spf.delta_w	if(!incontact_ap3,spf.d_w_plus*down(spf.mu)/(down(spf.rho)*max(spf.u_tau,sqrt(eps))),0)	m	Wall lift-off	Boundary 41	
spf.delta_w	if(!incontact_ap3,spf.d_w_plus*down(spf.mu)/(down(spf.rho)*max(spf.u_tau,sqrt(eps))),0)	m	Wall lift-off	Boundary 12	
spf.uStar	if(!incontact_ap3,spf.u_tau,0)	m/s	Friction velocity	Boundary 41	
spf.uStar	if(!incontact_ap3,spf.u_tau,0)	m/s	Friction velocity	Boundary 12	
spf.Delta_wPlus	if(!incontact_ap3,spf.d_w_plus,0)	1	Wall resolution in viscous units	Boundary 41	
spf.Delta_wPlus	if(!incontact_ap3,spf.d_w_plus,0)	1	Wall resolution in viscous units	Boundary 12	
spf.WRHeightExpr	if(!incontact_ap3,-11.06+spf.d_w_plus,0)	1	Wall resolution height expression	Boundary 41	
spf.WRHeightExpr	if(!incontact_ap3,-11.06+spf.d_w_plus,0)	1	Wall resolution height expression	Boundary 12	

Weak expressions

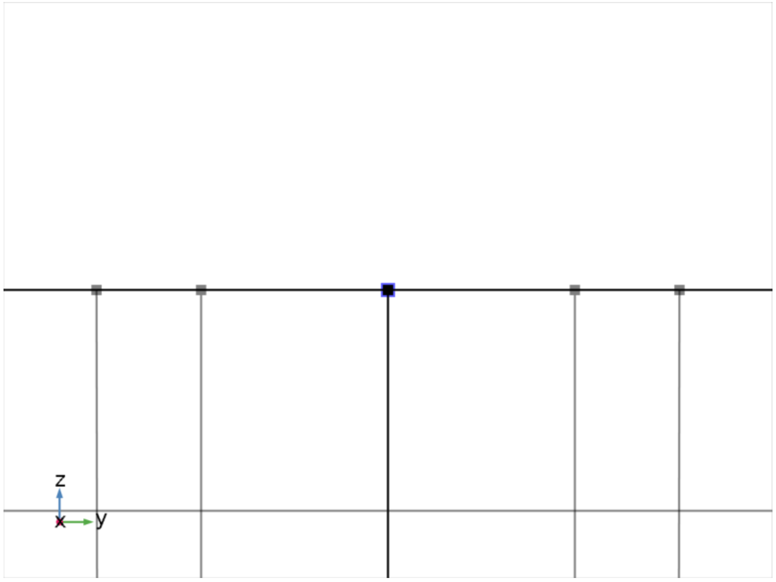
Weak expression	Integration order	Integration frame	Selection

Weak expression	Integration order	Integration frame	Selection
if(!incontact_ap3,spf.KStressn_avx*test(spf.u_herex)+spf.KStressn_avy*test(spf.u_herey)+spf.KStressn_avz*test(spf.u_herez)+spf.KStressTestn_avx*spf.ujumpx+spf.KStressTestn_avy*spf.ujumpy+spf.KStressTestn_avz*spf.ujumpz-spf.sigma_dg_ns*spf.unJump*test(spf.un_here)+spf.upwind_ns+spf.upwindCont+spf.consFlux,0)	2	Spatial	Boundary 41
if(!incontact_ap3,spf.KStressn_avx*test(spf.u_herex)+spf.KStressn_avy*test(spf.u_herey)+spf.KStressn_avz*test(spf.u_herez)+spf.KStressTestn_avx*spf.ujumpx+spf.KStressTestn_avy*spf.ujumpy+spf.KStressTestn_avz*spf.ujumpz-spf.sigma_dg_ns*spf.unJump*test(spf.un_here)+spf.upwind_ns+spf.upwindCont+spf.consFlux,0)	2	Spatial	Boundary 12
if(!incontact_ap3,down(spf.rho)*spf.u_tau*(-spf.u_tangx*test(u)-spf.u_tangy*test(v)-spf.u_tangz*test(w))/spf.uPlus,0)	2	Spatial	Boundary 41
if(!incontact_ap3,down(spf.rho)*spf.u_tau*(-spf.u_tangx*test(u)-spf.u_tangy*test(v)-spf.u_tangz*test(w))/spf.uPlus,0)	2	Spatial	Boundary 12

Constraints

Constraint	Constraint force	Shape function	Selection	Details
if(!incontact_ap3,-ep2+spf.ep_w,0)	if(!incontact_ap3,test(-ep2),0)	Lagrange (Linear)	Boundary 41	Elemental
if(!incontact_ap3,-ep2+spf.ep_w,0)	if(!incontact_ap3,test(-ep2),0)	Lagrange (Linear)	Boundary 12	Elemental

2.4.8 Pressure Point Constraint 1



Pressure Point Constraint 1

SELECTION

Geometric entity level	Point
Selection	Geometry geom1: Dimension 0: Point 1

EQUATIONS

$$p2 = (p_0 + p_{\mathrm{hydro}})$$

$$p_{\mathrm{hydro}} = \rho_{\mathrm{ref}}\, \mathbf{g} \cdot (\mathbf{r} - \mathbf{r}_{\mathrm{ref}})$$

Pressure constraint

SETTINGS

Description	Value
Pressure	0
Compensate for hydrostatic pressure	On

Variables

Name	Expression	Unit	Description	Selection
spf.p0	spf.p_hydro	Pa	Pressure	Point 1

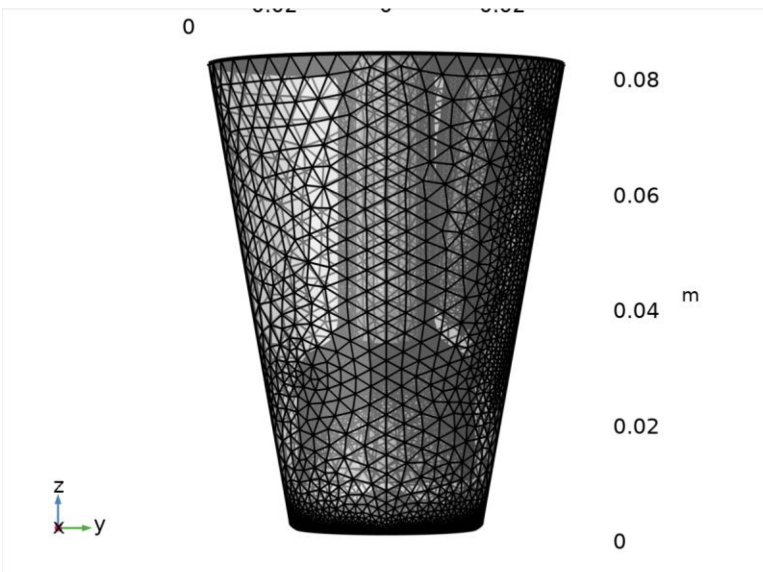
Constraints

Constraint	Constraint force	Shape function	Selection	Details
-p2+spf.p0	test(-p2)	Lagrange (Linear)	Point 1	Elemental

2.5 MESH 1

MESH STATISTICS

Description	Value
Minimum element quality	0.0238
Average element quality	0.6845
Tetrahedron	1279384
Pyramid	1311
Prism	315551
Triangle	85446
Quad	380
Edge element	4900
Vertex element	155



Mesh 1

2.5.1 Size (size)

SETTINGS

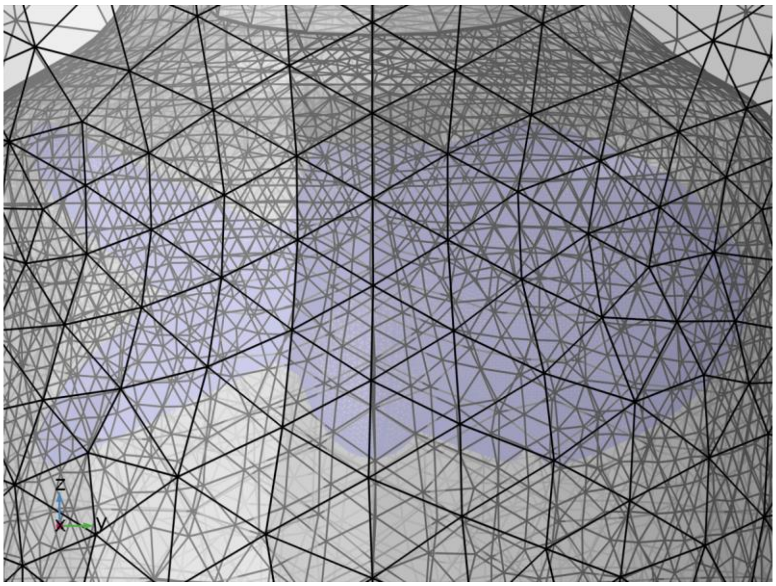
Description	Value
Calibrate for	Fluid dynamics
Maximum element size	0.005
Minimum element size	mf1
Curvature factor	0.6
Resolution of narrow regions	0.7
Maximum element growth rate	1.3

Description	Value
Custom element size	Custom

2.5.2 Rührer (size1)

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundaries 42–61, 67–71, 75–85, 89, 92, 94–114



Rührer

SETTINGS

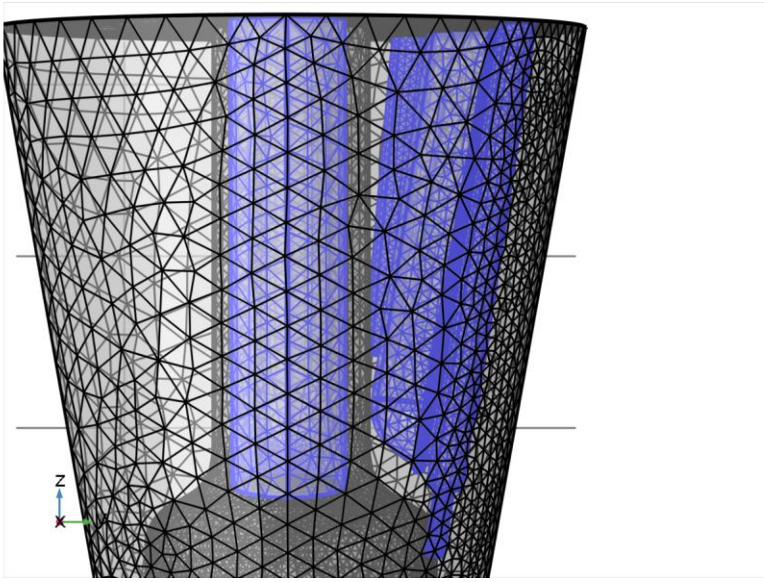
Description	Value
Calibrate for	Fluid dynamics
Maximum element size	3E-4
Minimum element size	mf1
Curvature factor	0.5
Resolution of narrow regions	0.8
Maximum element growth rate	1.2
Predefined size	Finer
Custom element size	Custom

2.5.3 Shaft+Sonden (size2)

SELECTION

Geometric entity level	Boundary

Selection	Geometry geom1: Dimension 2: Boundaries 3–7, 9–10, 13–15, 17–19, 21–22, 24–28, 30–33, 35–40, 63–66, 72–74, 86–88, 90–91, 93



Shaft+Sonden

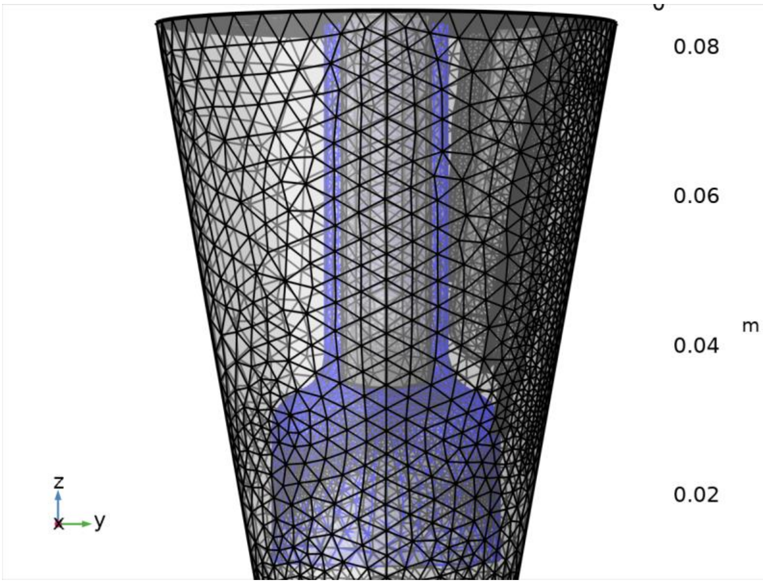
SETTINGS

Description	Value
Calibrate for	Fluid dynamics
Maximum element size	0.003
Minimum element size	1E-4
Curvature factor	0.5
Resolution of narrow regions	0.8
Maximum element growth rate	1.2
Custom element size	Custom

2.5.4 Rotationsgebiet (size3)

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundary 12



Rotationsgebiet

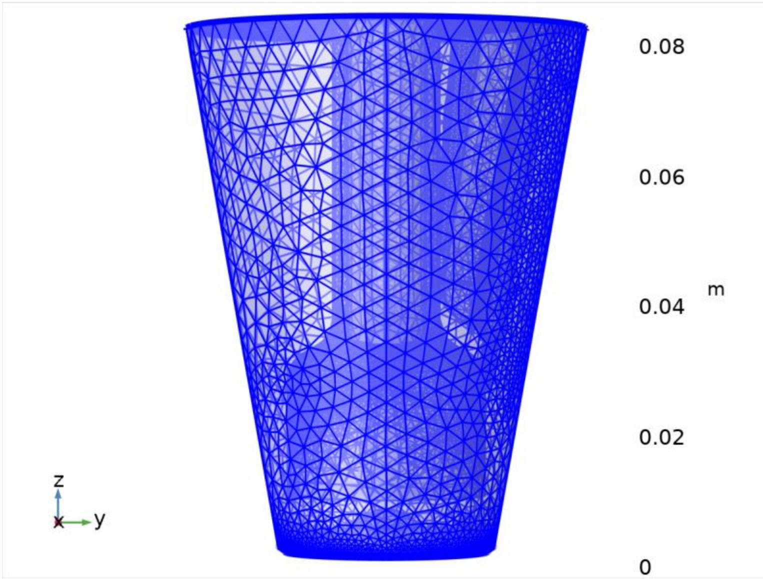
SETTINGS

Description	Value
Calibrate for	Fluid dynamics
Maximum element size	0.003
Minimum element size	mf2
Curvature factor	0.2
Maximum element growth rate	1.2
Custom element size	Custom

2.5.5 Corner Refinement 1 (cr1)

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: Domains 1–2

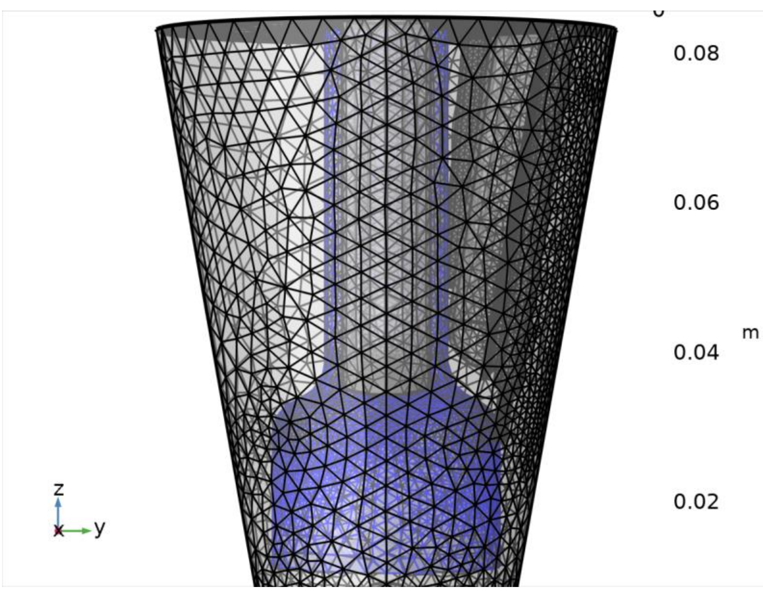


Corner Refinement 1

2.5.6 Free Tetrahedral 1 (ftet1)

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: Domain 2



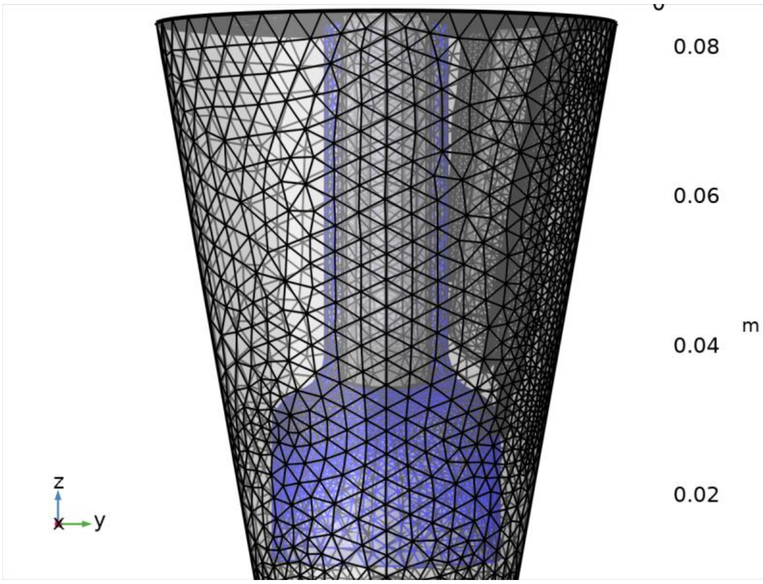
Free Tetrahedral 1

Size 1 (size1)

SELECTION

Geometric entity level	Domain

Selection	Geometry geom1: Dimension 3: Domain 2



Size 1

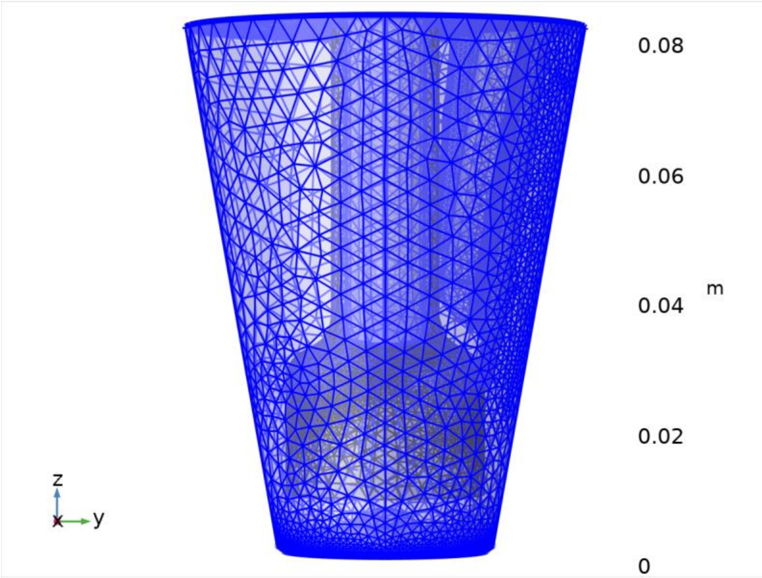
SETTINGS

Description	**Value**
Calibrate for	Fluid dynamics
Maximum element size	0.003
Minimum element size	mf2
Curvature factor	0.5
Resolution of narrow regions	0.8
Maximum element growth rate	1.2
Custom element size	Custom

2.5.7 Free Tetrahedral 2 (ftet2)

SELECTION

Geometric entity level	Domain
Selection	Remaining

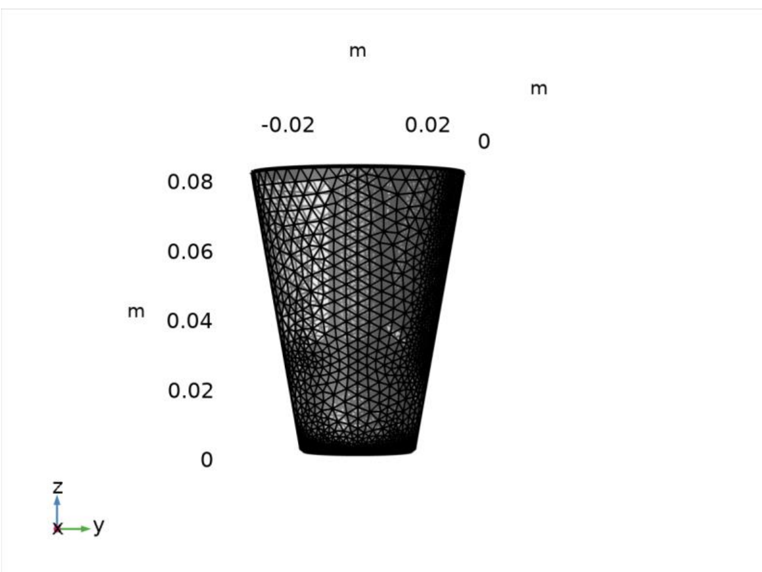


Free Tetrahedral 2

2.5.8 Boundary Layers 1 (bl1)

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1



Boundary Layers 1

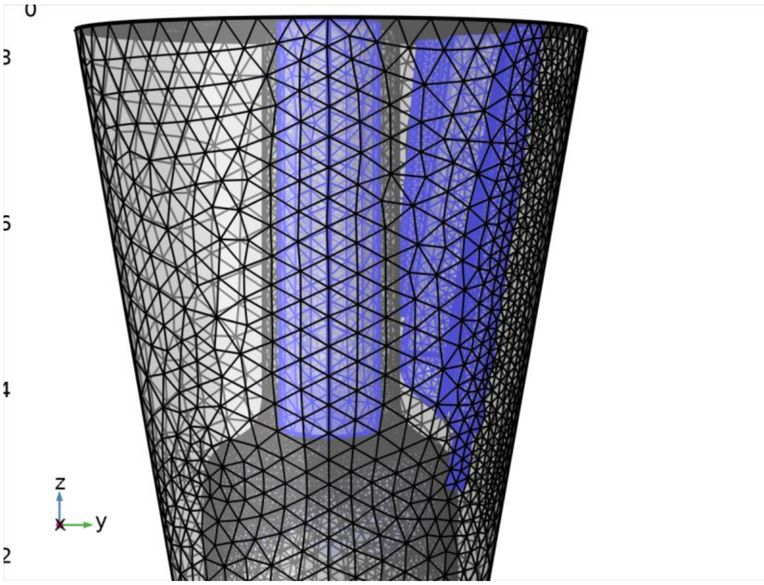
SETTINGS

Description	**Value**
Handling of sharp edges	Trimming

Boundary Layer Properties 1 (blp1)

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundaries 3–7, 9–10, 13–15, 17–19, 21–22, 24–40, 42–61, 63–114



Boundary Layer Properties 1

SETTINGS

Description	Value
Number of boundary layers	5
Thickness adjustment factor	2

3 Study 1

COMPUTATION INFORMATION

Computation time	8 h 17 min 17 s
CPU	Intel64 Family 6 Model 158 Stepping 9, 4 cores
Operating system	Windows 10

3.1 PARAMETRIC SWEEP GESCHWINDIGKEIT

Parameter name	Parameter value list	Parameter unit
f	range(100,100,800)	rpm

STUDY SETTINGS

Description	Value
Sweep type	Specified combinations
Parameter name	f
Unit	rpm

PARAMETERS

Parameter name	Parameter value list	Parameter unit
f	range(100,100,800)	rpm

3.2 PARAMETRIC MESH

Parameter name	Parameter value list	Parameter unit
mf1	range(8.0e-5,5.0e-6,1.2e-4)	m
mf2	range(8.0e-6,5.0e-6,1.2e-5)	m

STUDY SETTINGS

Description	Value
Sweep type	Specified combinations
Parameter name	{mf1, mf2}
Unit	{m, m}

PARAMETERS

Parameter name	Parameter value list	Parameter unit
mf1	range(8.0e-5,5.0e-6,1.2e-4)	m
mf2	range(8.0e-6,5.0e-6,1.2e-5)	m

3.3 FROZEN ROTOR

STUDY SETTINGS

Description	Value
Include geometric nonlinearity	On

PHYSICS AND VARIABLES SELECTION

Physics interface	Discretization
Turbulent Flow, k-ε (spf)	physics

MESH SELECTION

Geometry	Mesh
Geometry 1 (geom1)	mesh1

3.4 SOLVER CONFIGURATIONS

3.4.1 Solution 1

Compile Equations: Frozen Rotor (st1)

STUDY AND STEP

Description	Value
Use study	Study 1
Use study step	Frozen Rotor

LOG

```
<---- Compile Equations: Frozen Rotor in Study 1/Solution 1 (sol1) -------------
Started at Feb 16, 2021 2:01:13 PM.
Geometry shape order: Linear
Running on 2 x Intel(R) Xeon(R) CPU E5-2680 v3 at 2.50 GHz.
Using 2 sockets with 24 cores in total on g036.
Available memory: 128.55 GB.
Time: 4 s.
Physical memory: 2.36 GB
Virtual memory: 11.55 GB
Ended at Feb 16, 2021 2:01:17 PM.
----- Compile Equations: Frozen Rotor in Study 1/Solution 1 (sol1) ------------>
```

Dependent Variables 1 (v1)

GENERAL

Description	Value
Defined by study step	Frozen Rotor

INITIAL VALUE CALCULATION CONSTANTS

Constant name	Initial value source
f	range(100,100,800)[rpm]

LOG

```
<---- Dependent Variables 1 in Study 1/Solution 1 (sol1) -----------------------
Started at Feb 16, 2021 2:01:17 PM.
Solution time: 1 s.
Physical memory: 3.17 GB
Virtual memory: 11.55 GB
Ended at Feb 16, 2021 2:01:17 PM.
----- Dependent Variables 1 in Study 1/Solution 1 (sol1) ---------------------->
```

Turbulent dissipation rate (comp1.ep2) (comp1_ep2)

GENERAL

Description	Value
Field components	comp1.ep2

Turbulent kinetic energy (comp1.k2) (comp1_k2)

GENERAL

Description	Value
Field components	comp1.k2

Pressure (comp1.p2) (comp1_p2)

GENERAL

Description	Value
Field components	comp1.p2

Velocity field (spatial frame) (comp1.u) (comp1_u)

GENERAL

Description	Value
Field components	{comp1.u, comp1.v, comp1.w}
Internal variables	comp1.spf.isFluidHasBeenSolved

Stationary Solver 1 (s1)

GENERAL

Description	Value
Defined by study step	Frozen Rotor

LOG

```
0.087, 0.059
Residual error estimates for segregated groups
2.5e+02, 2.8e+04
Pseudo time-stepping CFL-ratio:
0.23
Segregated solver iteration 32.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.17   0.5000000        0.17 1043  518  518  4075   0.0004        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.064     4.4e+04   0.3500000       0.064 2516 1473 1473  8922  0.00065
     -
   2       0.056     3.5e+04   0.3500000       0.056 2517 1474 1474  8927  0.00097
     -
   3       0.051     2.8e+04   0.3500000       0.051 2518 1475 1475  8932  0.00091
     -
Solution error estimates for segregated groups
0.085, 0.058
Residual error estimates for segregated groups
2.3e+02, 2.8e+04
Pseudo time-stepping CFL-ratio:
0.24
Segregated solver iteration 33.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.16   0.5000000        0.16 1045  519  519  4082  0.00033        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.062     4.4e+04   0.3500000       0.062 2521 1476 1476  8940  0.00063
     -
   2       0.055     3.6e+04   0.3500000       0.055 2522 1477 1477  8945   0.0009
     -
   3        0.05       3e+04   0.3500000        0.05 2523 1478 1478  8950  0.00084
     -
Solution error estimates for segregated groups
0.082, 0.056
Residual error estimates for segregated groups
2e+02, 3e+04
Pseudo time-stepping CFL-ratio:
0.24
Segregated solver iteration 34.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.16   0.5000000        0.16 1047  520  520  4089  0.00041        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.061     4.6e+04   0.3500000       0.061 2526 1479 1479  8958  0.00063
     -
   2       0.054     3.8e+04   0.3500000       0.054 2527 1480 1480  8963  0.00081
     -
   3        0.05     3.3e+04   0.3500000        0.05 2528 1481 1481  8968  0.00078
     -
```

```
Solution error estimates for segregated groups
0.078, 0.055
Residual error estimates for segregated groups
1.9e+02, 3.3e+04
Pseudo time-stepping CFL-ratio:
0.24
Segregated solver iteration 35.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.15   0.5000000        0.15 1049  521  521  4096  0.00065        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1        0.06     4.9e+04   0.3500000        0.06 2531 1482 1482  8976  0.00066
     -
   2       0.054     4.2e+04   0.3500000       0.054 2532 1483 1483  8981  0.00078
     -
   3        0.05     3.8e+04   0.3500000        0.05 2533 1484 1484  8986  0.00077
     -
Solution error estimates for segregated groups
0.075, 0.055
Residual error estimates for segregated groups
1.7e+02, 3.8e+04
Pseudo time-stepping CFL-ratio:
0.25
Segregated solver iteration 36.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.15   0.5000000        0.15 1051  522  522  4103  0.00089        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.061     5.4e+04   0.3500000       0.061 2536 1485 1485  8994   0.0007
     -
   2       0.054     4.9e+04   0.3500000       0.054 2537 1486 1486  8999  0.00085
     -
   3       0.051     4.5e+04   0.3500000       0.051 2538 1487 1487  9004   0.0009
     -
Solution error estimates for segregated groups
0.073, 0.055
Residual error estimates for segregated groups
1.6e+02, 4.5e+04
Pseudo time-stepping CFL-ratio:
0.25
Segregated solver iteration 37.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.14   0.5000000        0.14 1053  523  523  4110    0.001        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.062     6.2e+04   0.3500000       0.062 2541 1488 1488  9012  0.00085
     -
   2       0.055     5.7e+04   0.3500000       0.055 2542 1489 1489  9018  0.00057
     -
```

```
   3       0.051     5.4e+04   0.3500000       0.051 2543 1490 1490  9024  0.00056
     -
Solution error estimates for segregated groups
0.07, 0.056
Residual error estimates for segregated groups
1.5e+02, 5.4e+04
Pseudo time-stepping CFL-ratio:
0.26
Segregated solver iteration 38.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.13   0.5000000        0.13 1055  524  524  4117  0.00094        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.062       7e+04   0.3500000       0.062 2546 1491 1491  9032  0.00099
     -
   2       0.056     6.6e+04   0.3500000       0.056 2547 1492 1492  9038  0.00073
     -
   3       0.053     6.4e+04   0.3500000       0.053 2548 1493 1493  9044  0.00067
     -
Solution error estimates for segregated groups
0.067, 0.057
Residual error estimates for segregated groups
1.4e+02, 6.4e+04
Pseudo time-stepping CFL-ratio:
0.26
Segregated solver iteration 39.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.13   0.5000000        0.13 1057  525  525  4125  0.00042        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.063     7.8e+04   0.3500000       0.063 2551 1494 1494  9052  0.00064
     -
   2       0.057     7.5e+04   0.3500000       0.057 2552 1495 1495  9058   0.0007
     -
   3       0.054     7.4e+04   0.3500000       0.054 2553 1496 1496  9064  0.00073
     -
Solution error estimates for segregated groups
0.064, 0.058
Residual error estimates for segregated groups
1.4e+02, 7.4e+04
Pseudo time-stepping CFL-ratio:
0.26
Segregated solver iteration 40.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.12   0.5000000        0.12 1059  526  526  4133   0.0006        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.064     8.5e+04   0.3500000       0.064 2556 1497 1497  9072  0.00073
     -
```

```
   2       0.057     8.3e+04   0.3500000       0.057 2557 1498 1498  9078  0.00082
    -
   3       0.054     8.4e+04   0.3500000       0.054 2558 1499 1499  9084  0.00082
    -
Solution error estimates for segregated groups
0.06, 0.058
Residual error estimates for segregated groups
1.4e+02, 8.4e+04
Pseudo time-stepping CFL-ratio:
0.27
Segregated solver iteration 41.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.12   0.5000000        0.12 1061  527  527  4141  0.00083        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.063     9.1e+04   0.3500000       0.063 2561 1500 1500  9092  0.00082
    -
   2       0.057       9e+04   0.3500000       0.057 2562 1501 1501  9098  0.00089
    -
   3       0.054     9.1e+04   0.3500000       0.054 2563 1502 1502  9104  0.00097
    -
Solution error estimates for segregated groups
0.058, 0.058
Residual error estimates for segregated groups
1.4e+02, 9.1e+04
Pseudo time-stepping CFL-ratio:
0.27
Segregated solver iteration 42.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.11   0.5000000        0.11 1063  528  528  4150  0.00052        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.062     9.5e+04   0.3500000       0.062 2566 1503 1503  9112  0.00085
    -
   2       0.056     9.4e+04   0.3500000       0.056 2567 1504 1504  9119  0.00061
    -
   3       0.054     9.5e+04   0.3500000       0.054 2568 1505 1505  9126  0.00055
    -
Solution error estimates for segregated groups
0.056, 0.057
Residual error estimates for segregated groups
1.5e+02, 9.5e+04
Pseudo time-stepping CFL-ratio:
0.28
Segregated solver iteration 43.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.11   0.5000000        0.11 1065  529  529  4159  0.00072        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
```

```
   1       0.06     9.6e+04   0.3500000       0.06 2571 1506 1506  9134   0.0009
    -
   2      0.055     9.5e+04   0.3500000      0.055 2572 1507 1507  9141  0.00057
    -
   3      0.053     9.7e+04   0.3500000      0.053 2573 1508 1508  9147    0.001
    -
Solution error estimates for segregated groups
0.053, 0.056
Residual error estimates for segregated groups
1.7e+02, 9.7e+04
Pseudo time-stepping CFL-ratio:
0.28
Segregated solver iteration 44.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.094   0.5000000      0.094 1067  530  530  4168  0.00095        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.058     9.4e+04   0.3500000      0.058 2576 1509 1509  9155  0.00092
    -
   2      0.053     9.4e+04   0.3500000      0.053 2577 1510 1510  9162  0.00058
    -
   3      0.051     9.4e+04   0.3500000      0.051 2578 1511 1511  9168  0.00098
    -
Solution error estimates for segregated groups
0.047, 0.054
Residual error estimates for segregated groups
1.7e+02, 9.4e+04
Pseudo time-stepping CFL-ratio:
0.29
Segregated solver iteration 45.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.085   0.5000000      0.085 1069  531  531  4178  0.00073        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.056     9.1e+04   0.3500000      0.056 2581 1512 1512  9176  0.00094
    -
   2      0.052       9e+04   0.3500000      0.052 2582 1513 1513  9183   0.0006
    -
   3       0.05       9e+04   0.3500000       0.05 2583 1514 1514  9189  0.00099
    -
Solution error estimates for segregated groups
0.042, 0.053
Residual error estimates for segregated groups
1.8e+02, 9e+04
Pseudo time-stepping CFL-ratio:
0.3
Segregated solver iteration 46.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.078   0.5000000      0.078 1071  532  532  4188  0.00078        -
Turbulence variables
```

```
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.053     8.6e+04   0.3500000       0.053 2586 1515 1515  9198  0.00058
     -
   2       0.049     8.5e+04   0.3500000       0.049 2587 1516 1516  9205  0.00061
     -
   3       0.047     8.4e+04   0.3500000       0.047 2588 1517 1517  9212  0.00058
     -
Solution error estimates for segregated groups
0.039, 0.05
Residual error estimates for segregated groups
1.6e+02, 8.4e+04
Pseudo time-stepping CFL-ratio:
0.31
Segregated solver iteration 47.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.074   0.5000000       0.074 1073  533  533  4198  0.00085        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.049     7.9e+04   0.3500000       0.049 2591 1518 1518  9221  0.00062
     -
   2       0.045     7.7e+04   0.3500000       0.045 2592 1519 1519  9228  0.00064
     -
   3       0.043     7.6e+04   0.3500000       0.043 2593 1520 1520  9235  0.00061
     -
Solution error estimates for segregated groups
0.037, 0.046
Residual error estimates for segregated groups
1.4e+02, 7.6e+04
Pseudo time-stepping CFL-ratio:
0.32
Segregated solver iteration 48.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.07   0.5000000        0.07 1075  534  534  4208  0.00099        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.044     7.1e+04   0.3500000       0.044 2596 1521 1521  9244  0.00065
     -
   2        0.04     6.8e+04   0.3500000        0.04 2597 1522 1522  9251  0.00066
     -
   3       0.038     6.6e+04   0.3500000       0.038 2598 1523 1523  9258  0.00063
     -
Solution error estimates for segregated groups
0.035, 0.042
Residual error estimates for segregated groups
1.3e+02, 6.6e+04
Pseudo time-stepping CFL-ratio:
0.32
Segregated solver iteration 49.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.065   0.5000000       0.065 1077  535  535  4219  0.00064        -
```

```
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.038     6.1e+04   0.3500000       0.038 2601 1524 1524  9267  0.00065
    -
   2       0.035     5.8e+04   0.3500000       0.035 2602 1525 1525  9274  0.00067
    -
   3       0.033     5.6e+04   0.3500000       0.033 2603 1526 1526  9281  0.00065
    -
Solution error estimates for segregated groups
0.032, 0.036
Residual error estimates for segregated groups
1.1e+02, 5.6e+04
Pseudo time-stepping CFL-ratio:
0.34
Segregated solver iteration 50.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.06   0.5000000        0.06 1079  536  536  4230   0.0007        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.032     5.1e+04   0.3500000       0.032 2606 1527 1527  9290  0.00061
    -
   2       0.029     4.8e+04   0.3500000       0.029 2607 1528 1528  9297  0.00067
    -
   3       0.027     4.5e+04   0.3500000       0.027 2608 1529 1529  9304  0.00065
    -
Solution error estimates for segregated groups
0.03, 0.03
Residual error estimates for segregated groups
1e+02, 4.5e+04
Pseudo time-stepping CFL-ratio:
0.35
Segregated solver iteration 51.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.058   0.5000000       0.058 1081  537  537  4241  0.00085        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.027     4.1e+04   0.3500000       0.027 2611 1530 1530  9313  0.00061
    -
   2       0.023     3.8e+04   0.3500000       0.023 2612 1531 1531  9320  0.00064
    -
   3       0.021     3.5e+04   0.3500000       0.021 2613 1532 1532  9327  0.00061
    -
Solution error estimates for segregated groups
0.029, 0.024
Residual error estimates for segregated groups
89, 3.5e+04
Pseudo time-stepping CFL-ratio:
0.37
Segregated solver iteration 52.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
```

```
   1       0.056   0.5000000       0.056 1083  538  538  4253  0.00071        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.022     3.2e+04   0.3500000       0.022 2616 1533 1533  9336  0.00063
     -
   2       0.019     2.9e+04   0.3500000       0.019 2617 1534 1534  9342  0.00096
     -
   3       0.016     2.7e+04   0.3500000       0.016 2618 1535 1535  9348  0.00091
     -
Solution error estimates for segregated groups
0.028, 0.02
Residual error estimates for segregated groups
86, 2.7e+04
Pseudo time-stepping CFL-ratio:
0.38
Segregated solver iteration 53.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.053   0.5000000       0.053 1085  539  539  4265  0.00087        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.019     2.5e+04   0.3500000       0.019 2621 1536 1536  9357  0.00063
     -
   2       0.015     2.2e+04   0.3500000       0.015 2622 1537 1537  9363  0.00078
     -
   3       0.013       2e+04   0.3500000       0.013 2623 1538 1538  9369  0.00072
     -
Solution error estimates for segregated groups
0.026, 0.016
Residual error estimates for segregated groups
90, 2e+04
Pseudo time-stepping CFL-ratio:
0.4
Segregated solver iteration 54.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.049   0.5000000       0.049 1087  540  540  4278  0.00067        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.017       2e+04   0.3500000       0.017 2626 1539 1539  9377  0.00099
     -
   2       0.013     1.7e+04   0.3500000       0.013 2627 1540 1540  9383  0.00063
     -
   3        0.01     1.4e+04   0.3500000        0.01 2628 1541 1541  9389  0.00056
     -
Solution error estimates for segregated groups
0.024, 0.014
Residual error estimates for segregated groups
1e+02, 1.4e+04
Pseudo time-stepping CFL-ratio:
0.41
Segregated solver iteration 55.
Velocity u, Pressure p2
```

```
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.044   0.5000000       0.044 1089  541  541  4291  0.00077        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.015     1.7e+04   0.3500000       0.015 2631 1542 1542  9397  0.00086
     -
   2       0.011     1.3e+04   0.3500000       0.011 2632 1543 1543  9402  0.00097
     -
   3      0.0089     1.1e+04   0.3500000      0.0089 2633 1544 1544  9407  0.00087
     -
Solution error estimates for segregated groups
0.022, 0.012
Residual error estimates for segregated groups
1.1e+02, 1.1e+04
Pseudo time-stepping CFL-ratio:
0.43
Segregated solver iteration 56.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.038   0.5000000       0.038 1091  542  542  4304  0.00089        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.013     1.4e+04   0.3500000       0.013 2636 1545 1545  9415  0.00081
     -
   2      0.0097     1.1e+04   0.3500000      0.0097 2637 1546 1546  9420  0.00089
     -
   3      0.0078       9e+03   0.3500000      0.0078 2638 1547 1547  9425  0.00079
     -
Solution error estimates for segregated groups
0.019, 0.01
Residual error estimates for segregated groups
95, 9e+03
Pseudo time-stepping CFL-ratio:
0.45
Segregated solver iteration 57.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.033   0.5000000       0.033 1093  543  543  4317    0.001        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.011     1.2e+04   0.3500000       0.011 2641 1548 1548  9433  0.00076
     -
   2      0.0083     9.4e+03   0.3500000      0.0083 2642 1549 1549  9438  0.00082
     -
   3      0.0068     7.7e+03   0.3500000      0.0068 2643 1550 1550  9443  0.00073
     -
Solution error estimates for segregated groups
0.016, 0.0089
Residual error estimates for segregated groups
84, 7.7e+03
Pseudo time-stepping CFL-ratio:
0.47
Segregated solver iteration 58.
```

```
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.027   0.5000000       0.027 1095  544  544  4331  0.00075        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0092       1e+04   0.3500000      0.0092 2646 1551 1551  9451  0.00068
     -
   2      0.0069       8e+03   0.3500000      0.0069 2647 1552 1552  9456  0.00075
     -
   3      0.0058     6.6e+03   0.3500000      0.0058 2648 1553 1553  9461  0.00068
     -
Solution error estimates for segregated groups
0.013, 0.0074
Residual error estimates for segregated groups
69, 6.6e+03
Pseudo time-stepping CFL-ratio:
0.49
Segregated solver iteration 59.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.021   0.5000000       0.021 1097  545  545  4345  0.00084        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0074     8.4e+03   0.3500000      0.0074 2651 1554 1554  9468  0.00096
     -
   2      0.0057     6.7e+03   0.3500000      0.0057 2652 1555 1555  9473   0.0007
     -
   3      0.0048     5.6e+03   0.3500000      0.0048 2653 1556 1556  9478  0.00064
     -
Solution error estimates for segregated groups
0.01, 0.0061
Residual error estimates for segregated groups
55, 5.6e+03
Pseudo time-stepping CFL-ratio:
0.52
Segregated solver iteration 60.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.016   0.5000000       0.016 1099  546  546  4359  0.00088        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0059     6.8e+03   0.3500000      0.0059 2656 1557 1557  9485  0.00075
     -
   2      0.0046     5.5e+03   0.3500000      0.0046 2657 1558 1558  9490  0.00065
     -
   3      0.0041     4.7e+03   0.3500000      0.0041 2658 1559 1559  9495   0.0006
     -
Solution error estimates for segregated groups
0.008, 0.0049
Residual error estimates for segregated groups
43, 4.7e+03
Pseudo time-stepping CFL-ratio:
0.55
```

```
Segregated solver iteration 61.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.012   0.5000000       0.012 1101  547  547  4373  0.00086        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0047     5.5e+03   0.3500000      0.0047 2661 1560 1560  9501  0.00098
     -
   2      0.0037     4.5e+03   0.3500000      0.0037 2662 1561 1561  9506  0.00059
     -
   3      0.0033       4e+03   0.3500000      0.0033 2663 1562 1562  9511  0.00054
     -
Solution error estimates for segregated groups
0.0061, 0.0039
Residual error estimates for segregated groups
33, 4e+03
Pseudo time-stepping CFL-ratio:
0.58
Segregated solver iteration 62.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0091   0.5000000      0.0091 1103  548  548  4387  0.00077        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0037     4.3e+03   0.3500000      0.0037 2666 1563 1563  9517   0.0008
     -
   2      0.0029     3.7e+03   0.3500000      0.0029 2667 1564 1564  9522  0.00051
     -
   3      0.0027     3.2e+03   0.3500000      0.0027 2668 1565 1565  9526  0.00096
     -
Solution error estimates for segregated groups
0.0046, 0.0031
Residual error estimates for segregated groups
25, 3.2e+03
Pseudo time-stepping CFL-ratio:
0.61
Segregated solver iteration 63.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0067   0.5000000      0.0067 1105  549  549  4400  0.00095        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0028     3.4e+03   0.3500000      0.0028 2671 1566 1566  9532  0.00065
     -
   2      0.0023     2.9e+03   0.3500000      0.0023 2672 1567 1567  9536  0.00086
     -
   3       0.002     2.6e+03   0.3500000       0.002 2673 1568 1568  9540  0.00077
     -
Solution error estimates for segregated groups
0.0033, 0.0024
Residual error estimates for segregated groups
19, 2.6e+03
Pseudo time-stepping CFL-ratio:
```

```
0.65
Segregated solver iteration 64.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0048   0.5000000      0.0048 1107  550  550  4413  0.00073        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.002     2.7e+03   0.3500000       0.002 2676 1569 1569  9545  0.00096
     -
   2      0.0017     2.3e+03   0.3500000      0.0017 2677 1570 1570  9549  0.00067
     -
   3      0.0015       2e+03   0.3500000      0.0015 2678 1571 1571  9553  0.00061
     -
Solution error estimates for segregated groups
0.0024, 0.0018
Residual error estimates for segregated groups
14, 2e+03
Pseudo time-stepping CFL-ratio:
0.69
Segregated solver iteration 65.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0033   0.5000000      0.0033 1109  551  551  4424  0.00099        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0015       2e+03   0.3500000      0.0015 2681 1572 1572  9558  0.00074
     -
   2      0.0012     1.8e+03   0.3500000      0.0012 2682 1573 1573  9561  0.00097
     -
   3      0.0011     1.6e+03   0.3500000      0.0011 2683 1574 1574  9564  0.00092
     -
Solution error estimates for segregated groups
0.0016, 0.0013
Residual error estimates for segregated groups
12, 1.6e+03
Pseudo time-stepping CFL-ratio:
0.73
Segregated solver iteration 66.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0023   0.5000000      0.0023 1111  552  552  4434  0.00091        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.001     1.6e+03   0.3500000       0.001 2686 1575 1575  9569  0.00055
     -
   2     0.00089     1.4e+03   0.3500000     0.00089 2687 1576 1576  9572  0.00073
     -
Solution error estimates for segregated groups
0.0011, 0.00068
Residual error estimates for segregated groups
9.1, 1.4e+03
Pseudo time-stepping CFL-ratio:
0.78
```

```
Segregated solver iteration 67.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0014   0.5000000      0.0014 1113  553  553  4442  0.00098        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1     0.00086     1.3e+03   0.3500000     0.00086 2690 1577 1577  9576   0.0009
     -
Solution error estimates for segregated groups
0.00071, 0.00056
Residual error estimates for segregated groups
6.8, 1.3e+03
Pseudo time-stepping CFL-ratio:
0.84
Segregated solver iteration 68.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1     0.00094   0.5000000     0.00094 1115  554  554  4449  0.00084        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0008     1.3e+03   0.3500000      0.0008 2693 1578 1578  9580  0.00081
     -
Solution error estimates for segregated groups
0.00047, 0.00052
Residual error estimates for segregated groups
5.2, 1.3e+03
Pseudo time-stepping CFL-ratio:
0.89
Segregated solver iteration 69.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1     0.00061   0.5000000     0.00061 1117  555  555  4455  0.00083        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1     0.00072     1.2e+03   0.3500000     0.00072 2696 1579 1579  9584  0.00073
     -
Solution error estimates for segregated groups
0.0003, 0.00047
Residual error estimates for segregated groups
3.9, 1.2e+03
Pseudo time-stepping CFL-ratio:
0.94
Segregated solver iteration 70.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1     0.00041   0.5000000     0.00041 1119  556  556  4460  0.00079        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1     0.00065     1.1e+03   0.3500000     0.00065 2699 1580 1580  9588  0.00067
     -
Solution error estimates for segregated groups
0.00021, 0.00042
```

```
Residual error estimates for segregated groups
3, 1.1e+03
Pseudo time-stepping CFL-ratio:
0.99
Segregated solver iteration 71.
Velocity u, Pressure p2
Iter      SolEst      Damping     Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1     0.00029   0.5000000     0.00029 1121  557  557  4464  0.00085        -
Turbulence variables
Iter      SolEst      ResEst      Damping     Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1     0.00059       1e+03   0.3500000     0.00059 2702 1581 1581  9592  0.00061
     -
Solution error estimates for segregated groups
0.00014, 0.00039
Residual error estimates for segregated groups
2.3, 1e+03
Pseudo time-stepping CFL-ratio:
1
Solution time: 29832 s. (8 hours, 17 minutes, 12 seconds)
Physical memory: 15.06 GB
Virtual memory: 23.06 GB
Ended at Feb 16, 2021 10:18:29 PM.
----- Stationary Solver 1 in Study 1/Solution 1 (sol1) ------------------------>
```

Advanced (aDef)

ASSEMBLY SETTINGS

Description	Value
Reuse sparsity pattern	On

Parametric 1 (p1)

GENERAL

Description	Value
Defined by study step	Parametric Sweep Geschwindigkeit
Run continuation for	No parameter

PARAMETERS

Parameter name	Parameter value list	Parameter unit
f	range(100,100,800)	rpm

Segregated 1 (se1)

GENERAL

Description	Value
Maximum number of iterations	400
Stabilization and acceleration	Pseudo time-stepping
Initial CFL number	3

Velocity u, Pressure p2 (ss1)

GENERAL

Description	Value
Variables	{Velocity field (spatial frame) (comp1.u), Pressure (comp1.p2)}
Linear solver	AMG, fluid flow variables (spf)

METHOD AND TERMINATION

Description	Value
Damping factor	0.5

Turbulence variables (ss2)

GENERAL

Description	Value
Variables	{Turbulent kinetic energy (comp1.k2), Turbulent dissipation rate (comp1.ep2)}
Linear solver	AMG, turbulence variables (spf)

METHOD AND TERMINATION

Description	Value
Damping factor	0.35
Termination technique	Iterations or tolerance
Number of iterations	3
Tolerance factor	1

Lower Limit 1 (ll1)

LOWER LIMIT

Description	Value
Lower limits (field variables)	comp1.k2 0 comp1.ep2 0

AMG, fluid flow variables (spf) (i1)

GENERAL

Description	Value
Nonlinear-based error norm	On
Maximum number of iterations	200

ERROR

Description	Value
Factor in error estimate	20

Multigrid 1 (mg1)

GENERAL

Description	Value
Solver	Smoothed aggregation AMG
Maximum number of DOFs at coarsest level	80000
Strength of connections	0.02
Construct prolongators componentwise	On
Prolongator smoothing	Off

Presmoother (pr)

SCGS 1 (sc1)

MAIN

Description	Value
Sweep type	SSOR
Number of iterations	0
Vertex relaxation factor	0.7

Postsmoother (po)

SCGS 1 (sc1)

MAIN

Description	Value
Sweep type	SSOR
Number of iterations	1
Vertex relaxation factor	0.7

Coarse Solver (cs)

Direct 1 (d1)

GENERAL

Description	Value
Solver	PARDISO
Pivoting perturbation	1.0E-13

AMG, turbulence variables (spf) (i2)

GENERAL

Description	Value
Nonlinear-based error norm	On
Maximum number of iterations	200

ERROR

Description	Value
Factor in error estimate	20

Multigrid 1 (mg1)

GENERAL

Description	Value
Solver	Smoothed aggregation AMG
Maximum number of DOFs at coarsest level	50000
Construct prolongators componentwise	On
Prolongator smoothing	Off

Presmoother (pr)

SOR Line 1 (sl1)

MAIN

Description	Value
Sweep type	SSOR
Number of iterations	0
Relaxation factor	0.7
Multivariable method	Uncoupled

SECONDARY

Description	Value
Relaxation factor	0.5

Postsmoother (po)

SOR Line 1 (sl1)

MAIN

Description	Value
Sweep type	SSOR
Number of iterations	1
Relaxation factor	0.7
Multivariable method	Uncoupled

SECONDARY

Description	Value
Relaxation factor	0.5

Coarse Solver (cs)

Direct 1 (d1)

GENERAL

Description	Value
Solver	PARDISO

Description	Value
Pivoting perturbation	1.0E-13

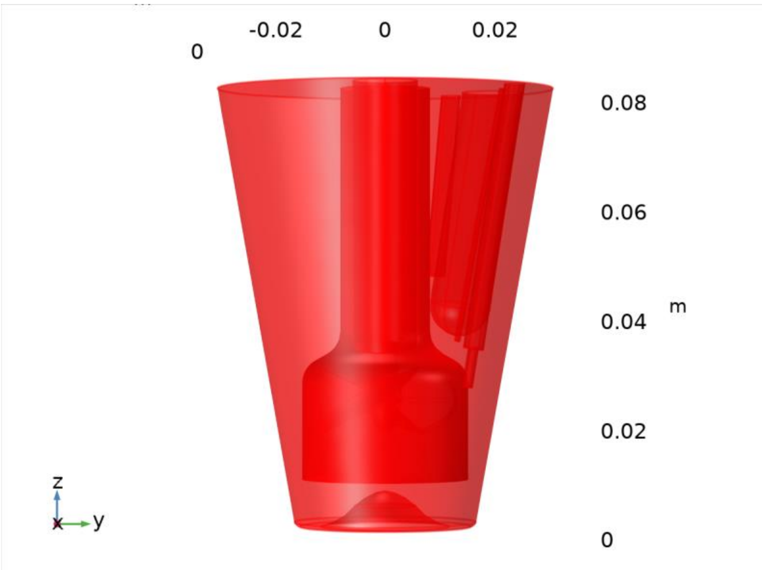
4 Results

4.1 DATASETS

4.1.1 Study 1/Solution 1 (1)

SOLUTION

Description	Value
Solution	Solution 1
Component	Save Point Geometry 1



Dataset: Study 1/Solution 1 (1)

4.1.2 Exterior Walls

DATA

Description	Value
Dataset	Study 1/Solution 1 (1)

PARAMETERIZATION

Description	Value
x- and y-axes	Surface parameters

4.1.3 Cut Plane 1

DATA

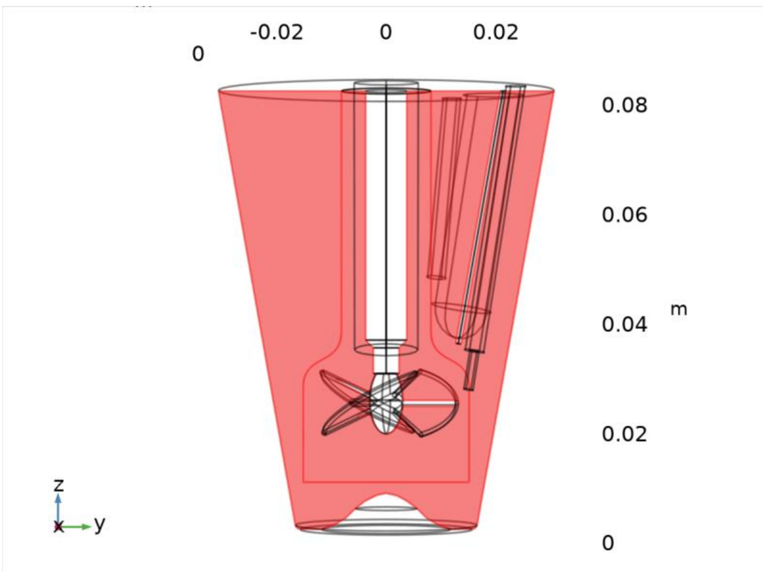
Description	Value
Dataset	Study 1/Solution 1 (1)

PLANE DATA

Description	Value
Plane type	Quick
x-coordinate	0

ADVANCED

Description	Value
Space variables	{cpl1x, cpl1y}
Normal variables	{cpl1nx, cpl1ny, cpl1nz}

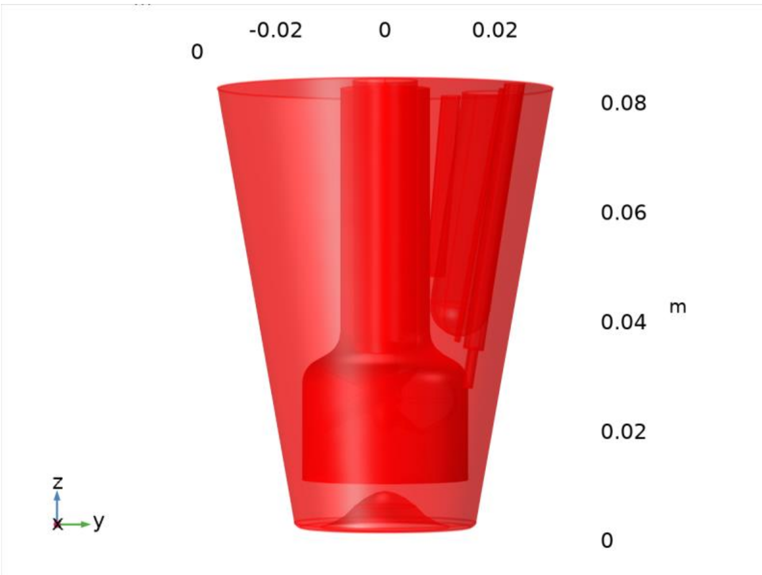


Dataset: Cut Plane 1

4.1.4 Mesh 1

MESH

Description	Value
Mesh	Mesh 1



Dataset: Mesh 1

4.1.5 Slice Plot

DATA

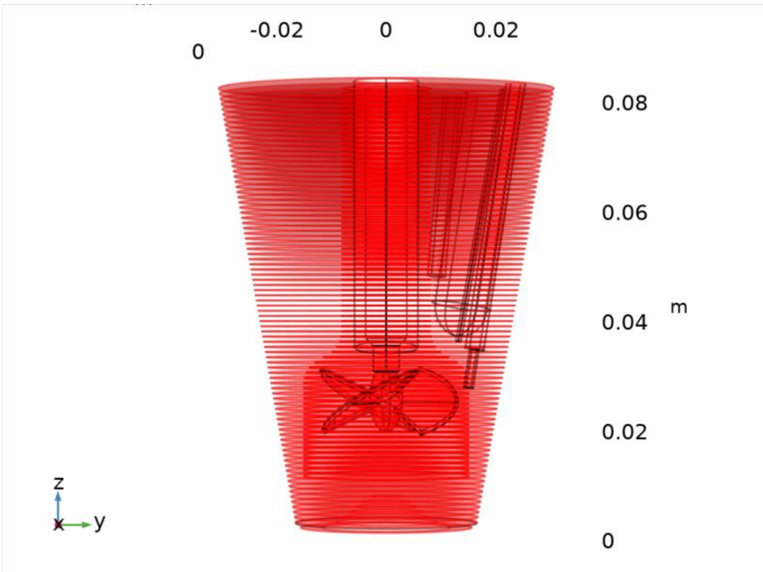
Description	Value
Dataset	Study 1/Solution 1 (1)

PLANE DATA

Description	Value
Plane type	Quick
Plane	xy - planes
z-coordinate	0
Additional parallel planes	On
Distances	{0.001, 0.002, 0.003, 0.004, 0.005, 0.006, 0.007, 0.008, 0.009000000000000001, 0.010000000000000002, 0.011, 0.012, 0.013000000000000001, 0.014000000000000002, 0.015, 0.016, 0.017, 0.018000000000000002, 0.019000000000000003, 0.02, 0.021, 0.022000000000000002, 0.023, 0.024, 0.025, 0.026000000000000002, 0.027000000000000003, 0.028, 0.029, 0.030000000000000002, 0.031, 0.032, 0.033, 0.034, 0.035, 0.036000000000000004, 0.037000000000000005, 0.038, 0.039, 0.04, 0.041, 0.042, 0.043000000000000003, 0.044000000000000004, 0.045, 0.046, 0.047, 0.048, 0.049, 0.05, 0.051000000000000004, 0.052000000000000005, 0.053000000000000005, 0.054, 0.055, 0.056, 0.057, 0.058, 0.059000000000000004, 0.060000000000000005, 0.061, 0.062, 0.063, 0.064, 0.065, 0.066, 0.067, 0.068, 0.069, 0.07, 0.07100000000000001, 0.07200000000000001, 0.07300000000000001, 0.074, 0.075, 0.076, 0.077, 0.078, 0.079, 0.08, 0.081, 0.082, 0.083, 0.084, 0.085}

ADVANCED

Description	Value
Space variables	{cpl2x, cpl2y}
Normal variables	{cpl2nx, cpl2ny, cpl2nz}

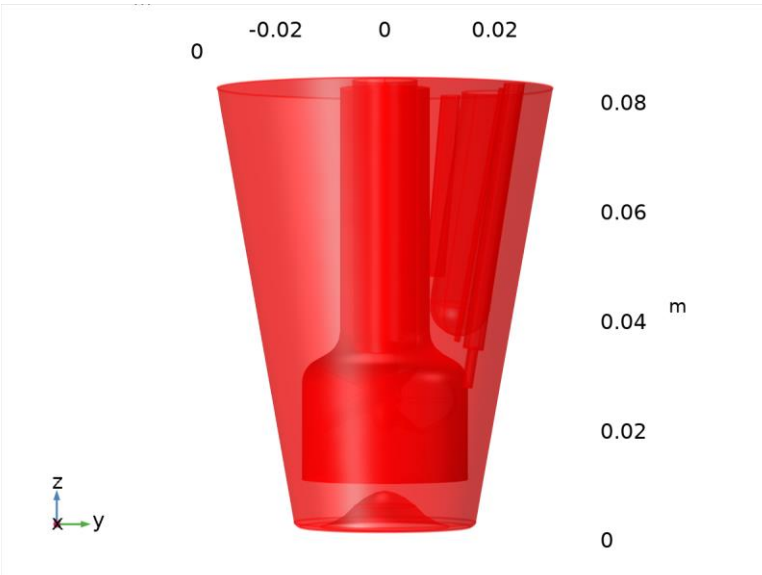


Dataset: Slice Plot

4.1.6 Study 1/Solution 1 (2)

SOLUTION

Description	Value
Solution	Solution 1
Component	Save Point Geometry 1



Dataset: Study 1/Solution 1 (2)

4.2 DERIVED VALUES

4.2.1 Volume Average 1

DATA

Description	Value
Dataset	Study 1/Solution 1 (1)

EXPRESSIONS

Expression	Unit	Description
spf.U	m/s	Velocity magnitude
spf.sr	1/s	Shear rate
spf.Qvd	W/m^3	Viscous dissipation

INTEGRATION SETTINGS

Description	Value
Integration order	4

4.2.2 Volume Maximum 1

DATA

Description	Value
Dataset	Study 1/Solution 1 (1)

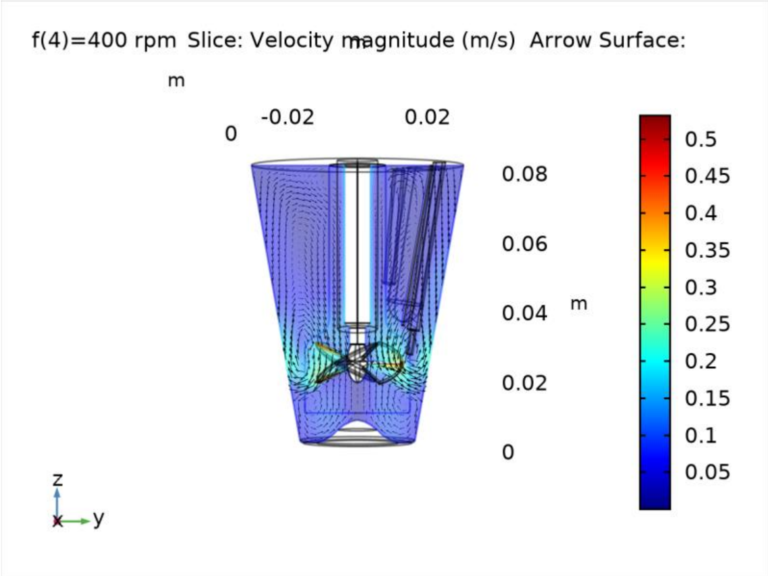
EXPRESSIONS

Expression	Unit	Description

Expression	Unit	Description
spf.U	m/s	Velocity magnitude
spf.sr	1/s	Shear rate
spf.Qvd	W/m^3	Viscous dissipation

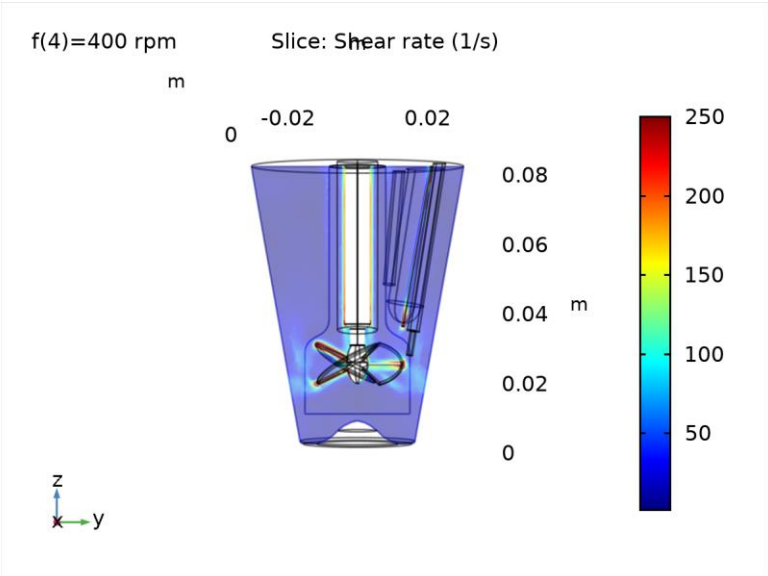
4.3 PLOT GROUPS

4.3.1 Geschwindigkeit



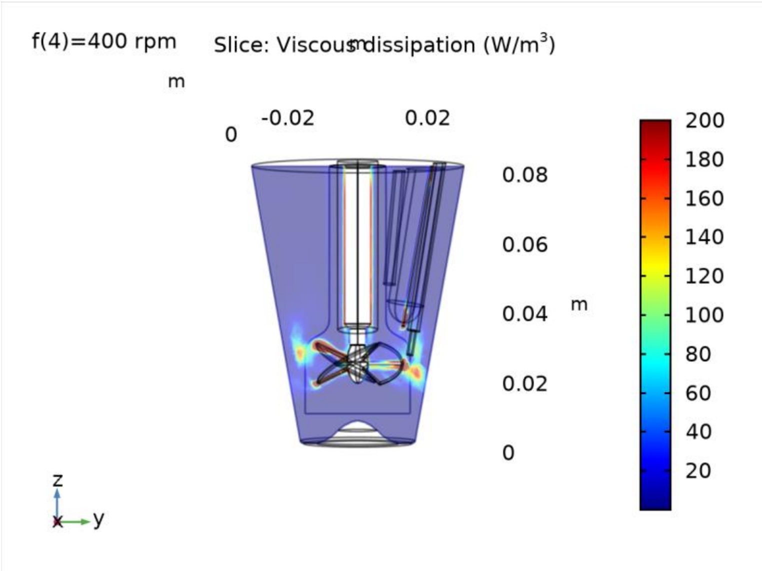
Slice: Velocity magnitude (m/s) Arrow Surface:

4.3.2 Scherrate



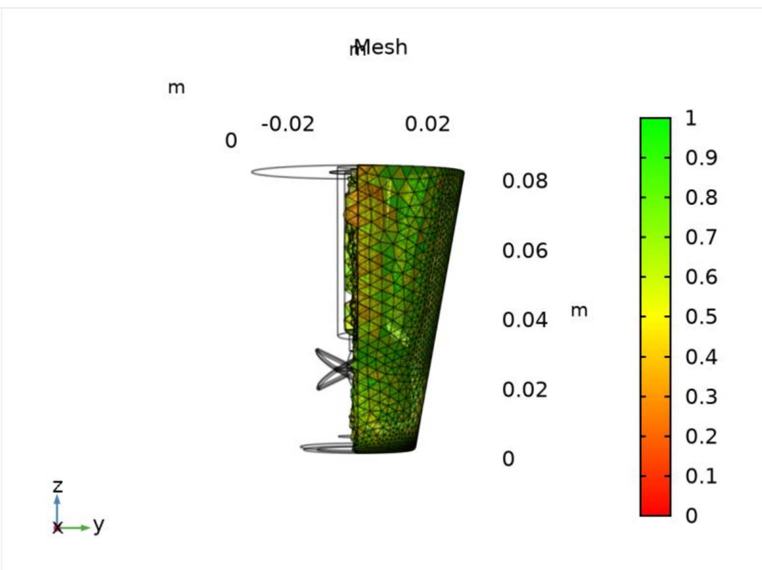
Slice: Shear rate (1/s)

4.3.3 Qvd



Slice: Viscous dissipation (W/m^3)

4.3.4 3D Plot Group 2



Mesh