Comsolout r s32a

Report date	Dec 4, 2021 7:39:23 PM

Contents

1 Global Definitions

Date	Feb 16, 2021 11:01:25 AM

GLOBAL SETTINGS

Name	Comsolout r s32a.mph
Path	E:\CFD Jens Budde\Cluster\3Blatt+Rushton+Rushton\comsolout_r_s32a.mph
Version	COMSOL Multiphysics 5.5 (Build: 359)
Unit system	SI

USED PRODUCTS

COMSOL Multiphysics
CAD Import Module
CFD Module

1.1 PARAMETERS

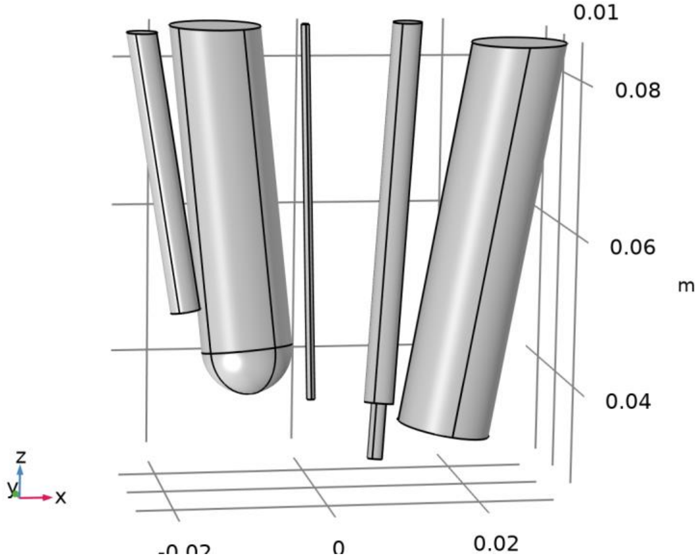
PARAMETERS 1

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	200 [rpm]	3.3333 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
pos_R2	3 [cm]	0.03 m	
pos_R3	4.5 [cm]	0.045 m	
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

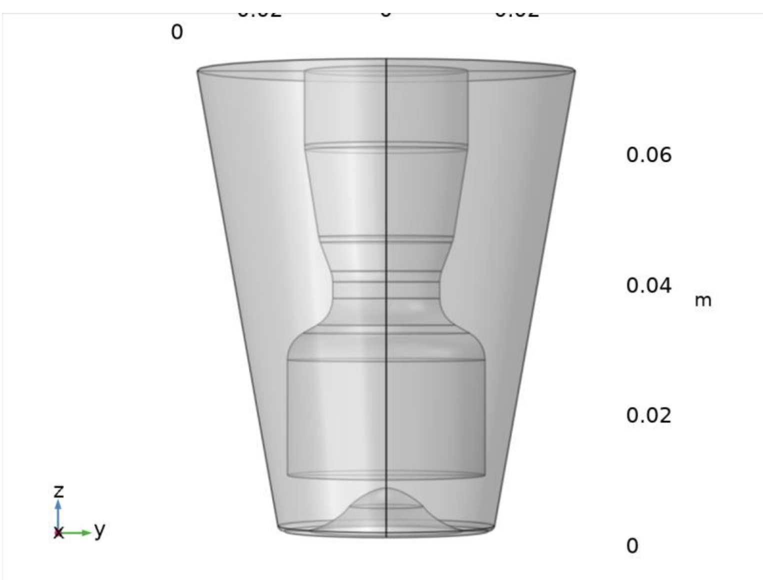
Description	Value
Radius	d_Beg/2

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	pos_R+pos_R2-0.0025-0.011
0.78*r_R	pos_R+pos_R2-0.0025-0.005
0.95*r_R	pos_R+pos_R2-0.0025+0.01
0.95*r_R	H
0	H

Abrundung 1 (fil1)

SETTINGS

Description	Value
Radius	0.005

Rotiert extrudieren 2 (rev2)

SETTINGS

Description	Value
Work plane	Arbeitsebene 2

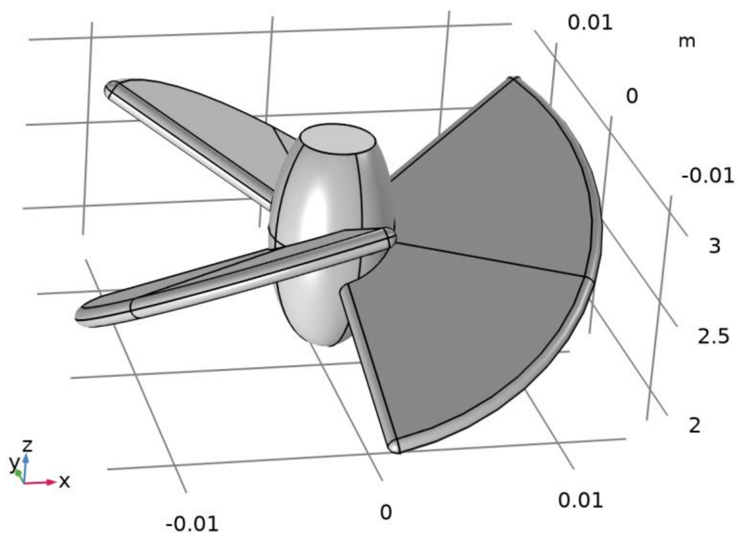
REVOLUTION ANGLES

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

1.2.5 Rushton

Rushton

UNITS

Length unit	mm
Angular unit	deg

GEOMETRY STATISTICS

Description	**Value**
Space dimension	3

Work Plane 1 (wp1)

UNITE OBJECTS

Description	**Value**
Unite objects	On

Plane Geometry (sequence2D)

Circle 1 (c1)

POSITION

Description	**Value**
Position	{0, 0}

SIZE AND SHAPE

Description	**Value**
Radius	d_S/2

Circle 2 (c2)

POSITION

Description	Value
Position	{0, 0}

SIZE AND SHAPE

Description	Value
Radius	6

Rectangle 1 (r1)

POSITION

Description	Value
Position	{4.5, -1}

SIZE

Description	Value
Width	7
Height	2

Rotate 1 (rot1)

SETTINGS

Description	Value
Angle	{0, 60, 120, 180, 240, 300}
Point on axis of rotation	{0, 0}

Union 1 (uni1)

COMPOSE

Description	Value
Keep interior boundaries	Off

Fillet 1 (fil1)

SETTINGS

Description	Value
Radius	1

Extrude 1 (ext1)

SETTINGS

Description	Value
Work plane	Work Plane 1

DISTANCES

Distances (mm)
5

SCALES

Scales xw	Scales yw
1	1

DISPLACEMENTS

Displacements xw (mm)	Displacements yw (mm)
0	0

TWIST ANGLES

Twist angles (deg)
0

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 7

Pair type	Identity pair
Pair name	ap7

SOURCE SELECTION

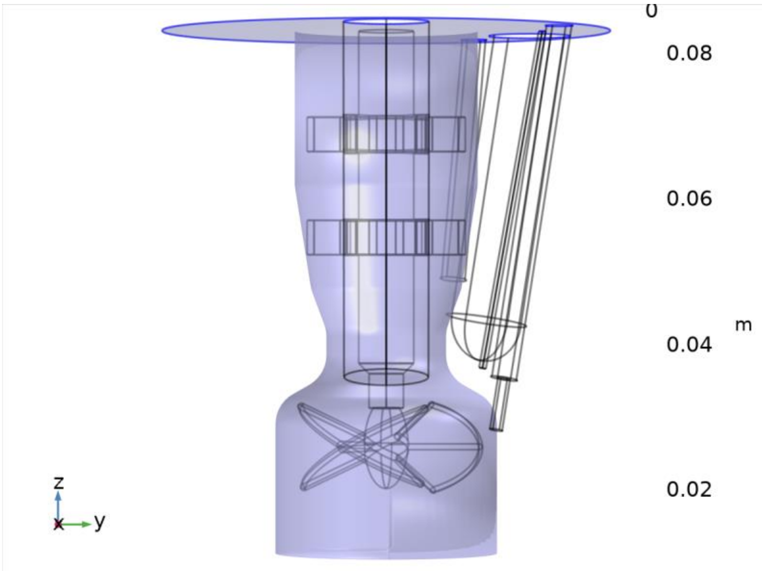
Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundary 2

DESTINATION SELECTION

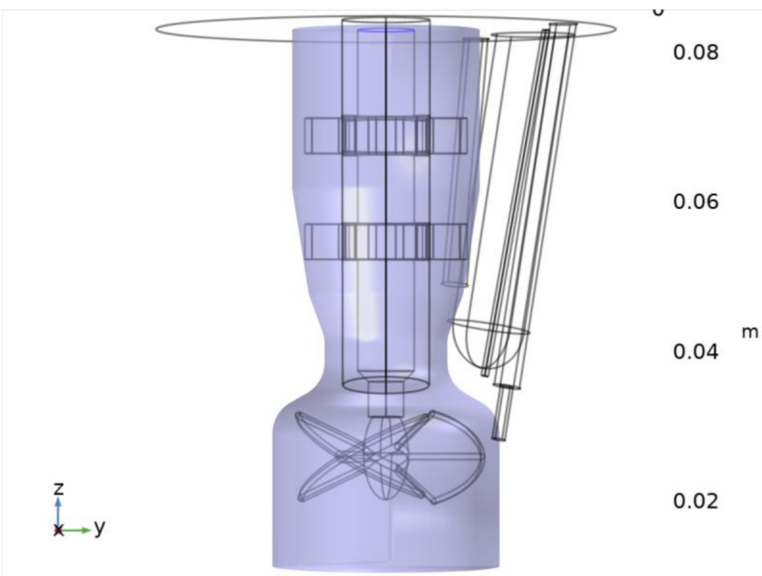
Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundary 40

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

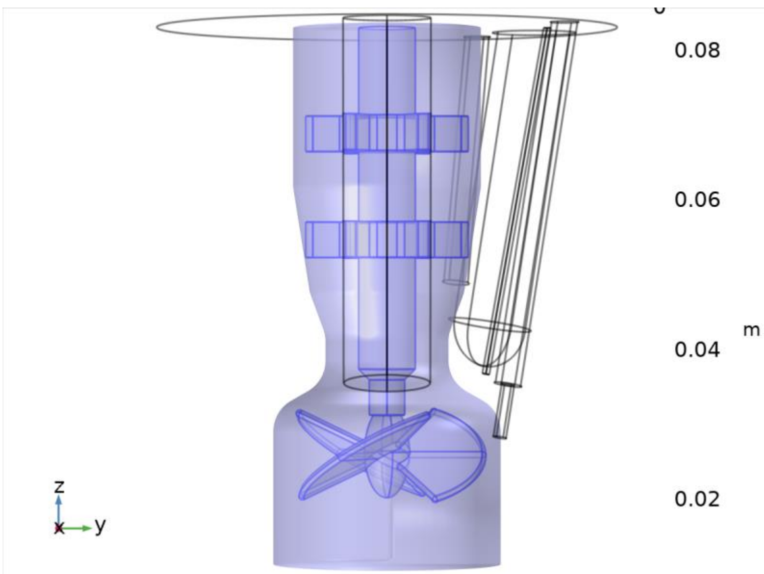
2.1.3 Moving Mesh

Rotating Domain 1

Tag	rot1

SELECTION

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



Selection

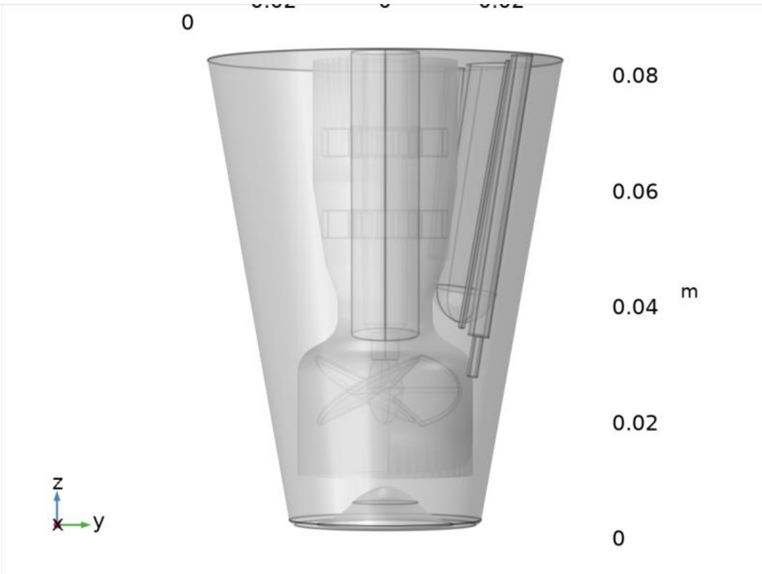
ROTATION

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	212
Number of edges	552
Number of vertices	359

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 Rushton 1 (pi9)

PART

Description	Value
Part	Rushton

POSITION AND ORIENTATION OF OUTPUT

Description	Value

Description	Value
Displacement	{0, 0, pos_R + pos_R2 - 0.0025}
Axis type	zw - axis
Rotation angle	30

SELECTION SETTINGS

Description	Value
Keep noncontributing selections	Off

2.2.4 Rushton 2 (pi10)

PART

Description	Value
Part	Rushton

POSITION AND ORIENTATION OF OUTPUT

Description	Value
Displacement	{0, 0, pos_R + pos_R3 - 0.0025}
Axis type	zw - axis
Rotation angle	30

SELECTION SETTINGS

Description	Value
Keep noncontributing selections	Off

2.2.5 Reaktorkessel 1 (pi5)

PART

Description	Value
Part	Reaktorkessel

POSITION AND ORIENTATION OF OUTPUT

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

SELECTION SETTINGS

Description	Value
Keep noncontributing selections	Off

2.2.6 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

2.2.7 Difference 1 (dif1)

SETTINGS

Description	Value
Keep input objects	On

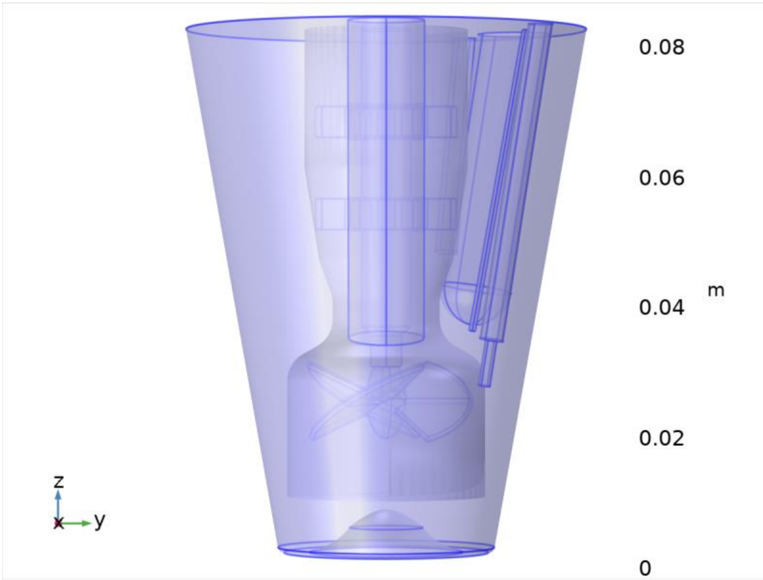
2.2.8 Form Assembly (fin)

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

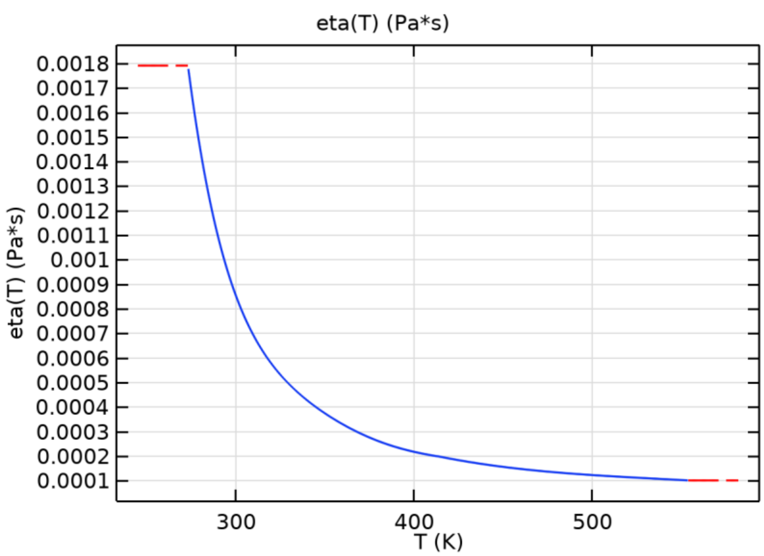
BASIC SETTINGS

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]}}

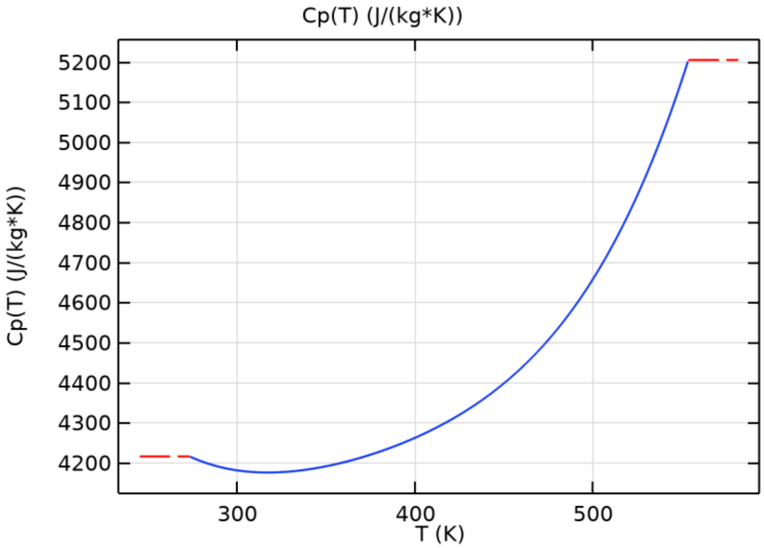
Description	Value
electricconductivity_symmetry	3
Heat capacity at constant pressure	Cp(T)
heatcapacity_symmetry	0
Density	rho(T)
density_symmetry	0
Thermal conductivity	{{k(T), 0, 0}, {0, k(T), 0}, {0, 0, k(T)}}
thermalconductivity_symmetry	3
Speed of sound	cs(T)
soundspeed_symmetry	0

FUNCTIONS

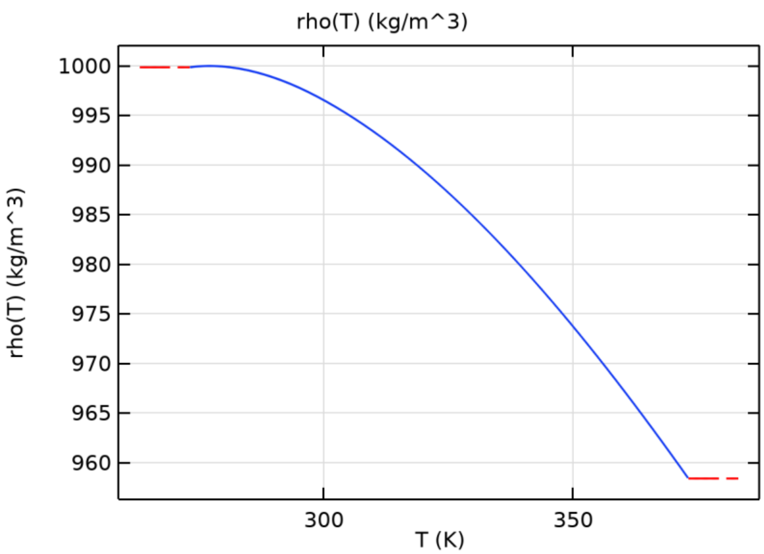
Function name	Type
eta	Piecewise
Cp	Piecewise
rho	Piecewise
k	Piecewise
cs	Interpolation
alpha_p	Analytic
gamma_w	Analytic
muB	Analytic



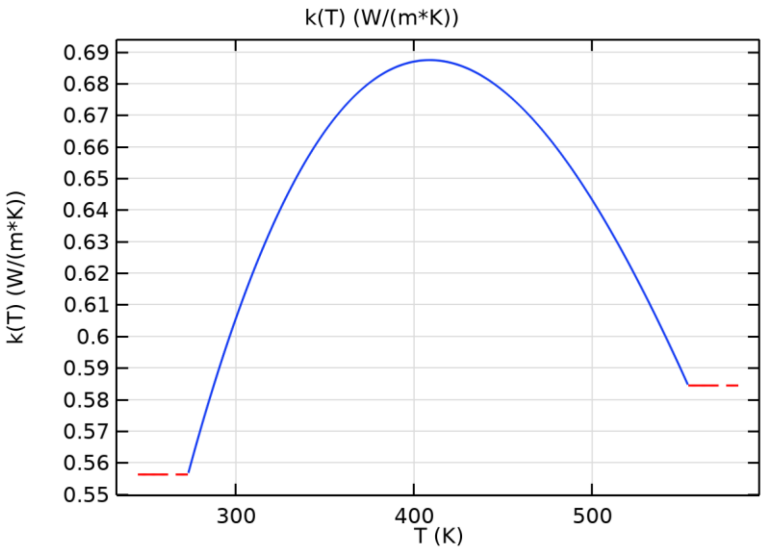
eta


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

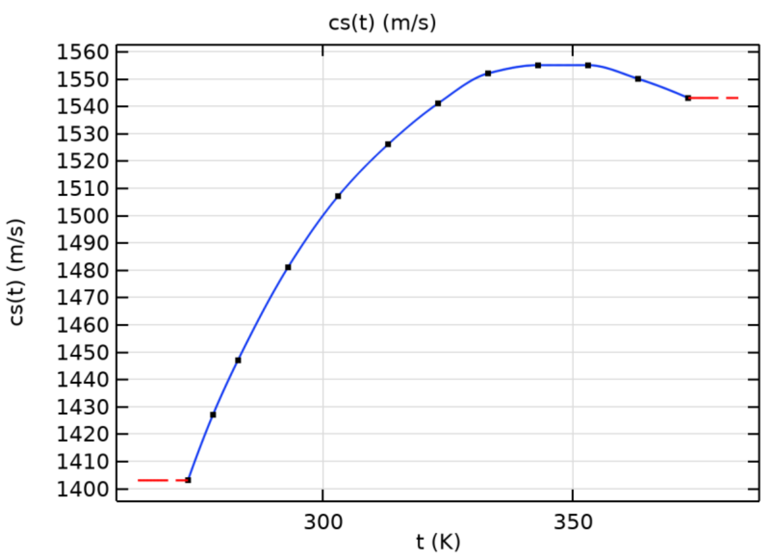
Cp


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

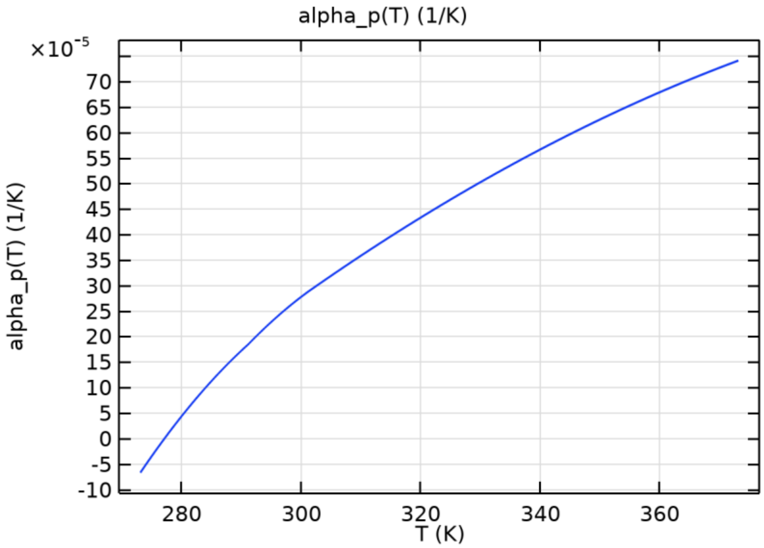
rho


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)

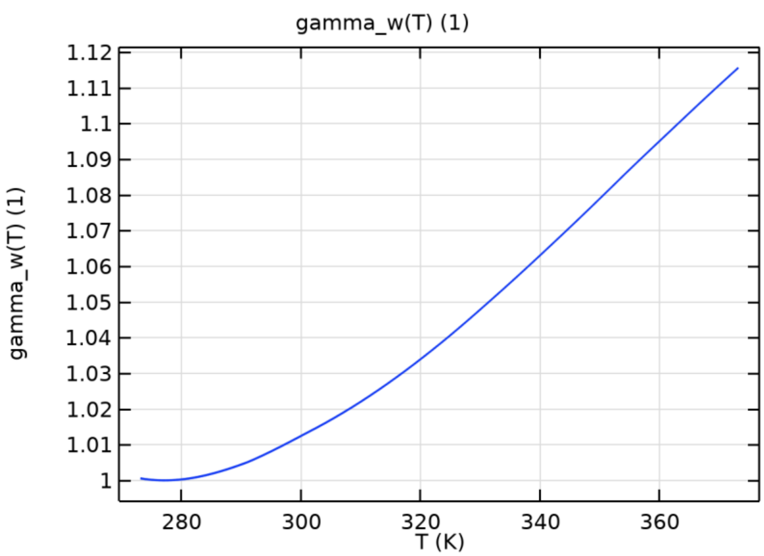
k


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)

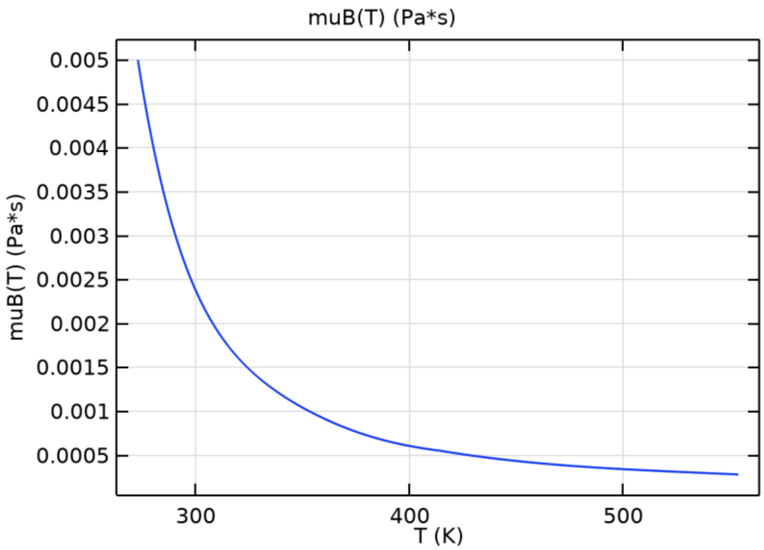
cs



alpha_p



gamma_w

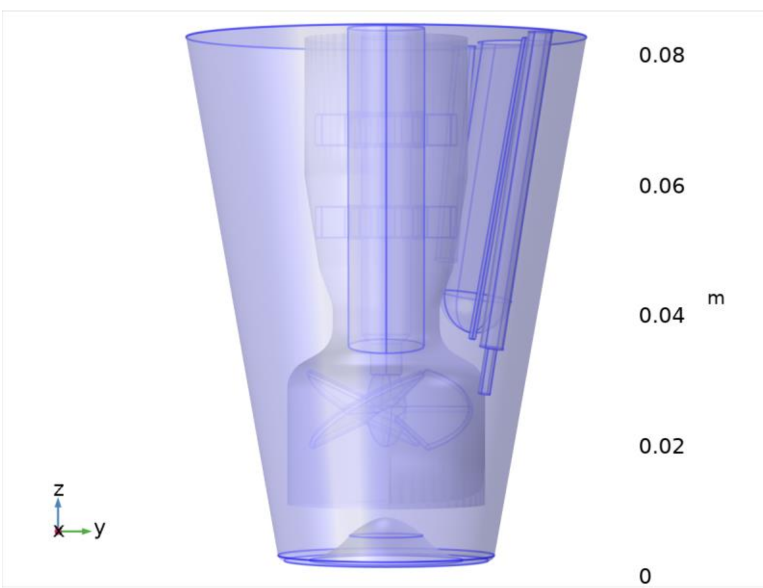


muB

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

$$\rho(\mathbf{u}\cdot\nabla)\mathbf{u}=\nabla\cdot[-p2\mathbf{I}+\mathbf{K}]+\mathbf{F}+\rho\mathbf{g}$$
$$\rho\nabla\cdot\mathbf{u}=0$$
$$\mathbf{K}=(\mu+\mu_T)\left(\nabla\mathbf{u}+(\nabla\mathbf{u})^T\right)$$
$$\rho(\mathbf{u}\cdot\nabla)k2=\nabla\cdot\left[\left(\mu+\frac{\mu_T}{\sigma_k}\right)\nabla k2\right]+P_k-\rho\epsilon$$
$$\rho(\mathbf{u}\cdot\nabla)\epsilon=\nabla\cdot\left[\left(\mu+\frac{\mu_T}{\sigma_\epsilon}\right)\nabla\epsilon\right]+C_{\epsilon1}\frac{\epsilon}{k2}P_k-C_{\epsilon2}\rho\frac{\epsilon^2}{k2},\quad \epsilon=\mathrm{ep2}$$

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

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

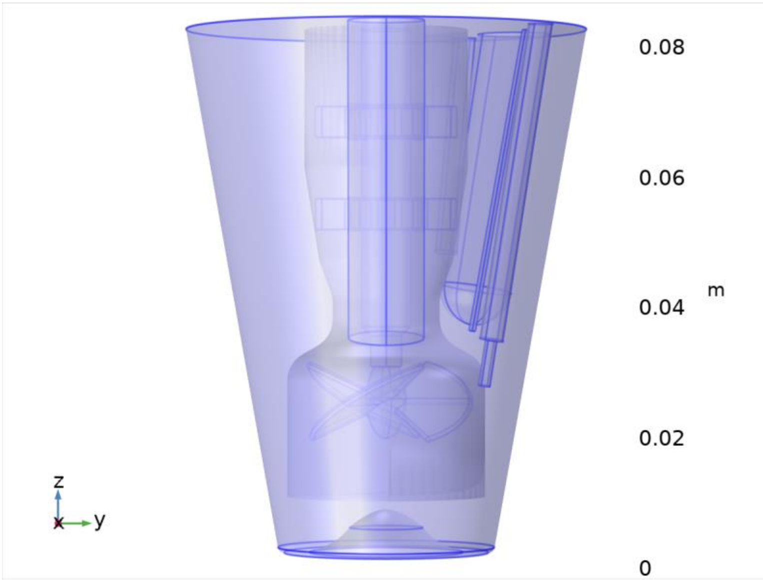
Description	Value
Edit turbulence model parameters	Off

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 1–212	
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 1–212	
spf.ny	dny	1	Normal vector, y component	Boundaries 1–212	
spf.nz	dnz	1	Normal vector, z component	Boundaries 1–212	
spf.nxmesh	dnxmesh	1	Normal vector, x component	Boundaries 1–212	
spf.nymesh	dnymesh	1	Normal vector, y component	Boundaries 1–212	
spf.nzmesh	dnzmesh	1	Normal vector, z component	Boundaries 1–212	

2.4.3 Fluid Properties 1



Fluid Properties 1

SELECTION

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

EQUATIONS

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

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

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

$$\rho(\mathbf{u}\cdot\nabla)k2 = \nabla\cdot\left[\left(\mu + \frac{\mu_T}{\sigma_k}\right)\nabla k2\right] + P_k - \rho\epsilon$$

$$\rho(\mathbf{u}\cdot\nabla)\epsilon = \nabla\cdot\left[\left(\mu + \frac{\mu_T}{\sigma_\epsilon}\right)\nabla\epsilon\right] + C_{\epsilon1}\frac{\epsilon}{k2}P_k - C_{\epsilon2}\rho\frac{\epsilon^2}{k2}, \quad \epsilon = \mathrm{ep2}$$

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)	$1/s^3$	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/s^2	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/s^2	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/s^2	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/s^3	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	m^2/s	Kinematic viscosity	Domains 1–2	
spf.betaT	0	1/Pa	Isothermal compressibility coefficient	Domains 1–2	
spf.Qm	0	$kg/(m^3 \cdot s)$	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/m^2	Total stress, x component	Boundaries 1–212	+ operation
spf.T_stressy	spf.K_stressy-p2*spf.nymesh	N/m^2	Total stress, y component	Boundaries 1–212	+ operation
spf.T_stressz	spf.K_stressz-p2*spf.nzmesh	N/m^2	Total stress, z component	Boundaries 1–212	+ operation
spf.K_stressx	spf.mu_eff*(2*ux*spf.nxmesh+(uy+vx)*spf.nymesh+(uz+wx)*spf.nzmesh)	N/m^2	Viscous stress, x component	Boundaries 1–212	+ operation
spf.K_stressy	spf.mu_eff*((vx+uy)*spf.nxmesh+2*vy*spf.nymesh+(vz+wy)*spf.nzmesh)	N/m^2	Viscous stress, y component	Boundaries 1–212	+ operation
spf.K_stressz	spf.mu_eff*((wx+uz)*	N/m^2	Viscous stress, z	Boundaries 1–	+ operation

Name	Expression	Unit	Description	Selection	Details
	spf.nxmesh+(wy+vz)*spf.nymesh+2*wz*spf.nzmesh)		component	212	
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/m^2	Viscous stress tensor test, zy component	Domains 1–2	+ operation
spf.K_stress_tensor_testxz	spf.mu_eff*(test(uz)+test(wx))	N/m^2	Viscous stress tensor test, xz component	Domains 1–2	+ operation
spf.K_stress_tensor_testyz	spf.mu_eff*(test(vz)+test(wy))	N/m^2	Viscous stress tensor test, yz component	Domains 1–2	+ operation
spf.K_stress_tensor_testzz	2*spf.mu_eff*test(wz)	N/m^2	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/m^3	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	m^2/s^2	Regularized turbulent kinetic energy	Domains 1–2	
spf.ep_nn	max(ep2,0)	m^2/s^3	Regularized turbulent dissipation rate	Domains 1–2	
spf.ep_pos	spf.ep_nn+eps	m^2/s^3		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/m^3	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/s^2		Domains 1–2	
spf.kinit	(10*spf.muinit/(spf.rhoinit*spf.l_mix_lim))^2	m^2/s^2	Turbulent kinetic energy	Domains 1–2	
spf.epinit	10*spf.C_mu*spf.kinit^1.5/spf.l_mix_lim	m^2/s^3	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	m^2/s^3	Turbulent dissipation rate, (all cells)	Domains 1–2	
spf.Pkb	spf.Pkb_mul*k2	W/m^3	Buoyancy-induced production of turbulence kinetic energy	Domains 1–2	+ operation
spf.Pkb_mul	0	$kg/(m^3 \cdot s)$	Help variable	Domains 1–2	+ operation
spf.Pepb_mul	0	$kg/(m^3 \cdot s)$	Help variable	Domains 1–2	+ operation
k2xt	k2xTIME-k2xx*d(x,TIME)-k2xy*d(y,TIME)-k2xz*d(z,TIME)	m/s^3	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/s^3	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/s^3	Gradient of k2, z component, first time derivative	Domains 1–2	
k2xtt	d(k2xTIME-	m/s^4	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/m³	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/s²	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/m³	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/m³	Equation residual	Domains 1–2	
spf.res_w	spf.rho*(wTIME-	N/m³	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

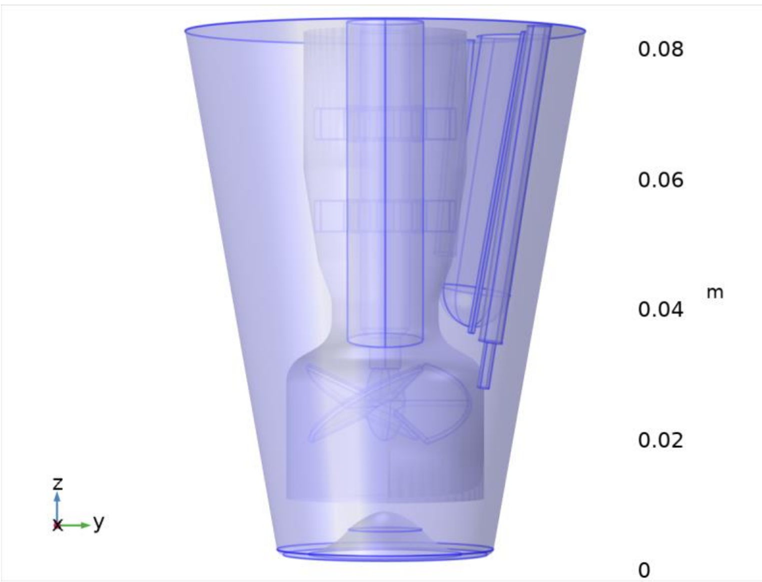
Weak expressions

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

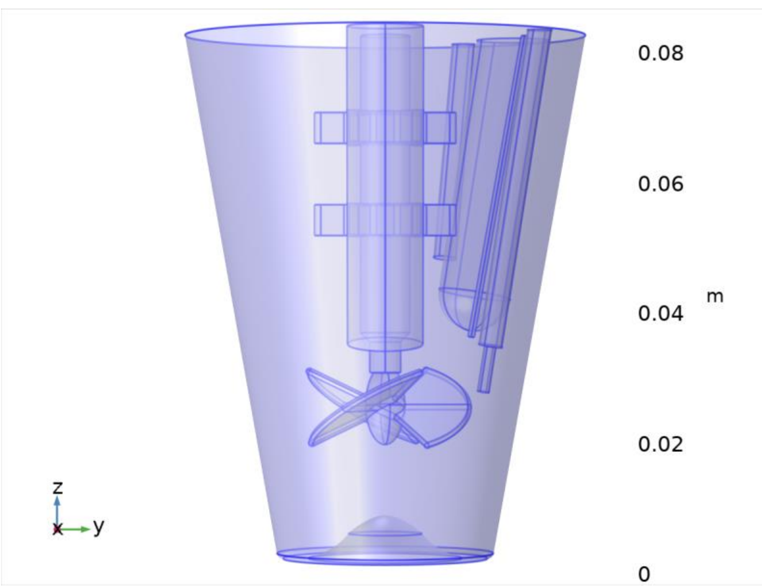
SETTINGS

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, 3–39, 41–212	
spf.k_nn	max(k2,0)	m^2/s^2	Regularized turbulent kinetic energy	Boundaries 1, 3–39, 41–212	
spf.ubndx	spf.utrx+spf.usx	m/s	Velocity at boundary, x component	Boundaries 1, 3–39, 41–212	
spf.ubndy	spf.utry+spf.usy	m/s	Velocity at boundary, y component	Boundaries 1, 3–39, 41–212	
spf.ubndz	spf.utrz+spf.usz	m/s	Velocity at boundary, z component	Boundaries 1, 3–39, 41–212	
spf.usx	0	m/s	Velocity of sliding wall, x component	Boundaries 1, 3–39, 41–212	

Name	Expression	Unit	Description	Selection	Details
spf.usy	0	m/s	Velocity of sliding wall, y component	Boundaries 1, 3–39, 41–212	
spf.usz	0	m/s	Velocity of sliding wall, z component	Boundaries 1, 3–39, 41–212	
spf.utrx	d(x,TIME)	m/s	Velocity of moving wall, x component	Boundaries 41–212	
spf.utry	d(y,TIME)	m/s	Velocity of moving wall, y component	Boundaries 41–212	
spf.utrz	d(z,TIME)	m/s	Velocity of moving wall, z component	Boundaries 41–212	
spf.utrx	0	m/s	Velocity of moving wall, x component	Boundaries 1, 3–39	
spf.utry	0	m/s	Velocity of moving wall, y component	Boundaries 1, 3–39	
spf.utrz	0	m/s	Velocity of moving wall, z component	Boundaries 1, 3–39	
spf.uLeakagex	0	m/s	Leakage velocity, x component	Boundaries 1, 3–39, 41–212	+ operation
spf.uLeakagey	0	m/s	Leakage velocity, y component	Boundaries 1, 3–39, 41–212	+ operation
spf.uLeakagez	0	m/s	Leakage velocity, z component	Boundaries 1, 3–39, 41–212	+ operation
spf.noSlipWall	1	1	Help variable	Boundaries 1, 3–39, 41–212	
spf.un_here	u*nojac(spf.nxmesh)+v*nojac(spf.nymesh)+w*nojac(spf.nzmesh)	m/s	Intermediate variable	Boundaries 1, 3–39, 41–212	
spf.u_herex	spf.un_here*nojac(spf.nxmesh)	m/s	Intermediate variable, x component	Boundaries 1, 3–39, 41–212	
spf.u_herey	spf.un_here*nojac(spf.nymesh)	m/s	Intermediate variable, y component	Boundaries 1, 3–39, 41–212	
spf.u_herez	spf.un_here*nojac(spf.	m/s	Intermediate	Boundaries 1,	

Name	Expression	Unit	Description	Selection	Details
	nzmesh)		variable, z component	3–39, 41–212	
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, 3–39, 41–212	
spf.u_therex	spf.un_there*nojac(spf.nxmesh)	m/s	Intermediate variable, x component	Boundaries 1, 3–39, 41–212	
spf.u_therey	spf.un_there*nojac(spf.nymesh)	m/s	Intermediate variable, y component	Boundaries 1, 3–39, 41–212	
spf.u_therez	spf.un_there*nojac(spf.nzmesh)	m/s	Intermediate variable, z component	Boundaries 1, 3–39, 41–212	
spf.unJump	spf.un_here-spf.un_there	m/s	Jump in normal velocity	Boundaries 1, 3–39, 41–212	
spf.KStressn_avx	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	Boundaries 1, 3–39, 41–212	
spf.KStressn_avy	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	Boundaries 1, 3–39, 41–212	
spf.KStressn_avz	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	Boundaries 1, 3–39, 41–212	
spf.KStressTestn_avx	spf.K_stress_tensor_testxx*spf.nxmesh+spf.K_stress_tensor_testxy*spf.nymesh+spf.K_stress_tensor_testxz*spf.nzmesh	N/m²	Average viscous stress, x component	Boundaries 1, 3–39, 41–212	
spf.KStressTestn_avy	spf.K_stress_tensor_testyx*spf.nxmesh+spf.K_stress_tensor_testyy	N/m²	Average viscous stress, y component	Boundaries 1, 3–39, 41–212	

Name	Expression	Unit	Description	Selection	Details
	*spf.nymesh+spf.K_stress_tensor_testyz*spf.nzmesh				
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/m²	Average viscous stress, z component	Boundaries 1, 3–39, 41–212	
spf.ujumpx	spf.u_herex-spf.u_therex	m/s	Velocity jump, x component	Boundaries 1, 3–39, 41–212	
spf.ujumpy	spf.u_herey-spf.u_therey	m/s	Velocity jump, y component	Boundaries 1, 3–39, 41–212	
spf.ujumpz	spf.u_herez-spf.u_therez	m/s	Velocity jump, z component	Boundaries 1, 3–39, 41–212	
spf.contCoeffFace	down(spf.contCoeff)	kg/m³	Help variable	Boundaries 1, 3–39, 41–212	
spf.rhoFace	down(spf.rho)	kg/m³	Density face value	Boundaries 1, 3–39, 41–212	
spf.c_here	36*nojac(down(spf.mu+spf.muT)/down(1))*spf.meshVol/spf.meshVolInt	Pa·s/m	Intermediate variable	Boundaries 1, 3–39, 41–212	
spf.meshVol	meshvol_spatial	m²		Boundaries 1, 3–39, 41–212	
spf.meshVolInt	down(meshvol_spatial)	m³	Volume of interior mesh element	Boundaries 1, 3–39, 41–212	
spf.sigma_dg_ns	4*spf.c_here	Pa·s/m		Boundaries 1, 3–39, 41–212	
spf.umxTnFace	(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)	m/s	Relative velocity on face	Boundaries 1, 3–39, 41–212	
spf.upwind_ns	spf.rhoFace*spf.umxTnFace*spf.unJump*test(spf.un_here)/down(1)^2	W/m²	Upwind term	Boundaries 1, 3–39, 41–212	

Name	Expression	Unit	Description	Selection	Details
spf.upwindCont	spf.contCoeffFace*spf.unJump*test(p2)	$kg^2/(m^3 \cdot s^3)$	Upwind term for continuity equation	Boundaries 1, 3–39, 41–212	
spf.pFace	p2	Pa	Pressure face value	Boundaries 1, 3–39, 41–212	
spf.consFlux	-spf.pFace*test(spf.un_here)	W/m^2	Conservative flux	Boundaries 1, 3–39, 41–212	+ 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, 3–39, 41–212	
spf.uPlus	log(spf.d_w_plus)/spf.kappav+spf.B	1	Tangential velocity in viscous units	Boundaries 1, 3–39, 41–212	+ operation
spf.mixLParam	spf.C_mu	1	Intermediate variable	Boundaries 1, 3–39, 41–212	
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, 3–39, 41–212	
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, 3–39, 41–212	
spf.u_tangx	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	Boundaries 1, 3–39, 41–212	
spf.u_tangy	v-spf.ubndy-spf.nymesh*((u-spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-	m/s	Velocity field, y component	Boundaries 1, 3–39, 41–212	

Name	Expression	Unit	Description	Selection	Details
	spf.ubndz)*spf.nzmesh)				
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, 3–39, 41–212	
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, 3–39, 41–212	
spf.uStar	spf.u_tau	m/s	Friction velocity	Boundaries 1, 3–39, 41–212	
spf.Delta_wPlus	spf.d_w_plus	1	Wall resolution in viscous units	Boundaries 1, 3–39, 41–212	
spf.WRHeightExpr	-11.06+spf.d_w_plus	1	Wall resolution height expression	Boundaries 1, 3–39, 41–212	

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.un_here)+spf.upwind_ns+spf.upwindCont+spf.consFlux	2	Spatial	Boundaries 1, 3–39, 41–212
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, 3–39, 41–212

Constraints

Constraint	Constraint force	Shape function	Selection	Details
-ep2+spf.ep_w	test(-ep2)	Lagrange (Linear)	Boundaries 1, 3–39, 41–212	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

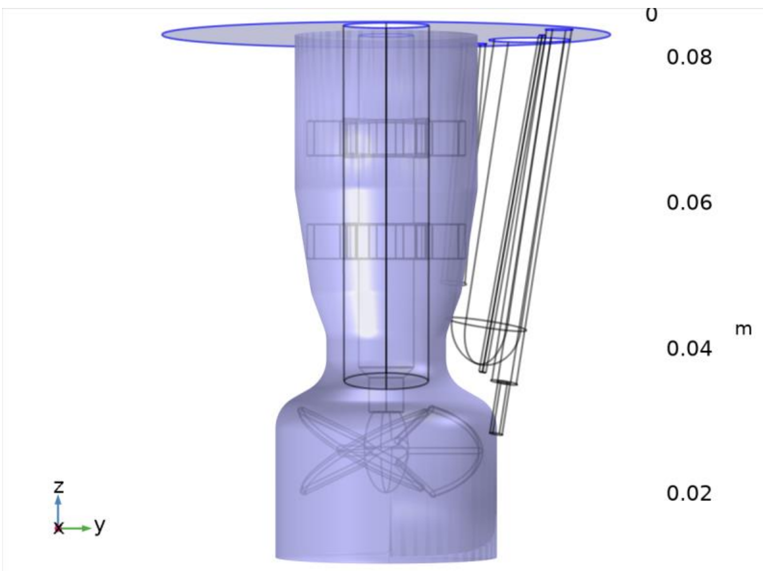
Name	Expression	Unit	Description	Selection	Details
spf.Fgtotx	spf.Fgx	N/m³	Gravity force, x component	Domains 1–2	+ operation
spf.Fgtoty	spf.Fgy	N/m³	Gravity force, y component	Domains 1–2	+ operation
spf.Fgtotz	spf.Fgz	N/m³	Gravity force, z component	Domains 1–2	+ operation
spf.gx	0	m/s²	Acceleration of gravity, x component	Global	
spf.gy	0	m/s²	Acceleration of gravity, y component	Global	
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

Name	Expression	Unit	Description	Selection	Details
spf.Pepbmph_mul	0	kg/(m^3·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 7 (ap7)

Variables

Name	Expression	Unit	Description	Selection	Details
spf.mu_here_ap7	down(spf.mu)	Pa·s	Dynamic viscosity	Boundary 2	
spf.mu_here_ap7	down(spf.mu)	Pa·s	Dynamic viscosity	Boundary 40	
spf.muT_here_ap7	spf.muT	Pa·s	Turbulent dynamic viscosity	Boundary 2	
spf.muT_here_ap7	spf.muT	Pa·s	Turbulent dynamic viscosity	Boundary 40	
spf.rho_here_ap7	down(spf.rho)	kg/m³	Density	Boundary 2	
spf.rho_here_ap7	down(spf.rho)	kg/m³	Density	Boundary 40	
spf.rho_there_ap7	src2dst_ap7(spf.rho_here_ap7)	kg/m³	Density	Boundary 40	
spf.rho_there_ap7	dst2src_ap7(spf.rho_here_ap7)	kg/m³	Density	Boundary 2	
spf.contCoeff_here_ap7	down(spf.contCoeff)	kg/m³	Help variable	Boundary 2	
spf.contCoeff_here_ap7	down(spf.contCoeff)	kg/m³	Help variable	Boundary 40	
spf.meshVolInt_ap7	down(meshvol_spatial)	m³	Volume of interior mesh element	Boundary 2	
spf.meshVolInt_ap7	down(meshvol_spatial)	m³	Volume of interior mesh element	Boundary 40	
spf.meshVol_ap7	meshvol_spatial	m²		Boundary 2	
spf.meshVol_ap7	meshvol_spatial	m²		Boundary 40	
spf.u_here_ap7x	u	m/s	Intermediate variable, x component	Boundary 2	
spf.u_here_ap7y	v	m/s	Intermediate variable, y component	Boundary 2	
spf.u_here_ap7z	w	m/s	Intermediate variable, z component	Boundary 2	
spf.u_here_ap7x	u	m/s	Intermediate	Boundary 40	

Name	Expression	Unit	Description	Selection	Details
			variable, x component		
spf.u_here_ap7y	v	m/s	Intermediate variable, y component	Boundary 40	
spf.u_here_ap7z	w	m/s	Intermediate variable, z component	Boundary 40	
spf.u_there_ap7x	src2dst_ap7(u)	m/s	Intermediate variable, x component	Boundary 40	
spf.u_there_ap7y	src2dst_ap7(v)	m/s	Intermediate variable, y component	Boundary 40	
spf.u_there_ap7z	src2dst_ap7(w)	m/s	Intermediate variable, z component	Boundary 40	
spf.u_there_ap7x	dst2src_ap7(u)	m/s	Intermediate variable, x component	Boundary 2	
spf.u_there_ap7y	dst2src_ap7(v)	m/s	Intermediate variable, y component	Boundary 2	
spf.u_there_ap7z	dst2src_ap7(w)	m/s	Intermediate variable, z component	Boundary 2	
spf.p_here_ap7	p2	Pa	Pressure	Boundary 2	
spf.p_here_ap7	p2	Pa	Pressure	Boundary 40	
spf.KStressn_here_ap7x	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 2	
spf.KStressn_here_ap7y	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 2	
spf.KStressn_here_ap7z	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 2	

Name	Expression	Unit	Description	Selection	Details
spf.KStressn_here_ap7x	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 40	
spf.KStressn_here_ap7y	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 40	
spf.KStressn_here_ap7z	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 40	
spf.KStressn_there_ap7x	src2dst_ap7(spf.K_stress_tensorxx)*spf.nxmesh+src2dst_ap7(spf.K_stress_tensorxy)*spf.nymesh+src2dst_ap7(spf.K_stress_tensorxz)*spf.nzmesh	N/m²	Average viscous stress, x component	Boundary 40	
spf.KStressn_there_ap7y	src2dst_ap7(spf.K_stress_tensoryx)*spf.nxmesh+src2dst_ap7(spf.K_stress_tensoryy)*spf.nymesh+src2dst_ap7(spf.K_stress_tensoryz)*spf.nzmesh	N/m²	Average viscous stress, y component	Boundary 40	
spf.KStressn_there_ap7z	src2dst_ap7(spf.K_stress_tensorzx)*spf.nxmesh+src2dst_ap7(spf.K_stress_tensorzy)*spf.nymesh+src2dst_ap7(spf.K_stress_tensorzz)*spf.nzmesh	N/m²	Average viscous stress, z component	Boundary 40	
spf.KStressn_there_ap7x	dst2src_ap7(spf.K_stress_tensorxx)*spf.nxmesh+dst2src_ap7(spf.K_stress_tensorxy)*spf.nymesh+dst2src_ap7(spf.K_stress_tensorxz)*spf.nzmesh	N/m²	Average viscous stress, x component	Boundary 2	
spf.KStressn_there_ap7y	dst2src_ap7(spf.K_stress_tensoryx)*spf.nx	N/m²	Average viscous stress, y	Boundary 2	

Name	Expression	Unit	Description	Selection	Details
	mesh+dst2src_ap7(spf.K_stress_tensoryy)*spf.nymesh+dst2src_ap7(spf.K_stress_tensoryz)*spf.nzmesh		component		
spf.KStressn_there_ap7z	dst2src_ap7(spf.K_stress_tensorzx)*spf.nxmesh+dst2src_ap7(spf.K_stress_tensorzy)*spf.nymesh+dst2src_ap7(spf.K_stress_tensorzz)*spf.nzmesh	N/m²	Average viscous stress, z component	Boundary 2	
spf.KStressn_av_ap7x	0.5*(spf.KStressn_here_ap7x+spf.KStressn_there_ap7x)	N/m²	Average viscous stress, x component	Boundary 2	
spf.KStressn_av_ap7y	0.5*(spf.KStressn_here_ap7y+spf.KStressn_there_ap7y)	N/m²	Average viscous stress, y component	Boundary 2	
spf.KStressn_av_ap7z	0.5*(spf.KStressn_here_ap7z+spf.KStressn_there_ap7z)	N/m²	Average viscous stress, z component	Boundary 2	
spf.KStressn_av_ap7x	0.5*(spf.KStressn_here_ap7x+spf.KStressn_there_ap7x)	N/m²	Average viscous stress, x component	Boundary 40	
spf.KStressn_av_ap7y	0.5*(spf.KStressn_here_ap7y+spf.KStressn_there_ap7y)	N/m²	Average viscous stress, y component	Boundary 40	
spf.KStressn_av_ap7z	0.5*(spf.KStressn_here_ap7z+spf.KStressn_there_ap7z)	N/m²	Average viscous stress, z component	Boundary 40	
spf.ujump_ap7x	spf.u_here_ap7x-spf.u_there_ap7x	m/s	Velocity jump, x component	Boundary 2	
spf.ujump_ap7y	spf.u_here_ap7y-spf.u_there_ap7y	m/s	Velocity jump, y component	Boundary 2	
spf.ujump_ap7z	spf.u_here_ap7z-spf.u_there_ap7z	m/s	Velocity jump, z component	Boundary 2	
spf.ujump_ap7x	spf.u_here_ap7x-spf.u_there_ap7x	m/s	Velocity jump, x component	Boundary 40	
spf.ujump_ap7y	spf.u_here_ap7y-spf.u_there_ap7y	m/s	Velocity jump, y component	Boundary 40	
spf.ujump_ap7z	spf.u_here_ap7z-spf.u_there_ap7z	m/s	Velocity jump, z component	Boundary 40	
spf.c_here_ap7	36*nojac((spf.mu_her	Pa·s/m		Boundary 2	

Name	Expression	Unit	Description	Selection	Details
	e_ap7+spf.muT_here_ap7)/spf.epsilon_p)*spf.meshVol_ap7/spf.meshVolInt_ap7				
spf.c_here_ap7	36*nojac((spf.mu_here_ap7+spf.muT_here_ap7)/spf.epsilon_p)*spf.meshVol_ap7/spf.meshVolInt_ap7	Pa·s/m		Boundary 40	
spf.sigma_dg_ns_ap7	spf.c_here_ap7+dst2src_ap7(spf.c_here_ap7)	Pa·s/m		Boundary 2	
spf.sigma_dg_ns_ap7	spf.c_here_ap7+src2dst_ap7(spf.c_here_ap7)	Pa·s/m		Boundary 40	
spf.rhoFace_ap7	0.5*(spf.rho_here_ap7+spf.rho_there_ap7)	kg/m³	Density face value	Boundary 2	
spf.rhoFace_ap7	0.5*(spf.rho_here_ap7+spf.rho_there_ap7)	kg/m³	Density face value	Boundary 40	
spf.rhoJump_ap7	spf.rho_here_ap7-spf.rho_there_ap7	kg/m³	Density face value	Boundary 2	
spf.rhoJump_ap7	spf.rho_here_ap7-spf.rho_there_ap7	kg/m³	Density face value	Boundary 40	
spf.contCoeffFace_ap7	0.5*(spf.contCoeff_here_ap7+dst2src_ap7(spf.contCoeff_here_ap7))	kg/m³	Help variable	Boundary 2	
spf.contCoeffFace_ap7	0.5*(spf.contCoeff_here_ap7+src2dst_ap7(spf.contCoeff_here_ap7))	kg/m³	Help variable	Boundary 40	
spf.umxTnFace_ap7	0.5*(spf.umxTn_here_ap7+spf.umxTn_there_ap7<0)*(spf.umxTn_here_ap7+spf.umxTn_there_ap7)	m/s	Relative velocity on face	Boundary 2	
spf.umxTnFace_ap7	0.5*(spf.umxTn_here_ap7+spf.umxTn_there_ap7<0)*(spf.umxTn_here_ap7+spf.umxTn_there_ap7)	m/s	Relative velocity on face	Boundary 40	
spf.umxTn_here_ap7	spf.upwind_helpx*spf.nxmesh+spf.upwind_helpy*spf.nymesh+sp	m/s	Relative velocity on face	Boundary 2	

Name	Expression	Unit	Description	Selection	Details
	f.upwind_helpz*spf.nzmesh				
spf.umxTn_here_ap7	spf.upwind_helpx*spf.nxmesh+spf.upwind_helpy*spf.nymesh+spf.upwind_helpz*spf.nzmesh	m/s	Relative velocity on face	Boundary 40	
spf.umxTn_there_ap7	dst2src_ap7(spf.upwind_helpx)*spf.nxmesh+dst2src_ap7(spf.upwind_helpy)*spf.nymesh+dst2src_ap7(spf.upwind_helpz)*spf.nzmesh	m/s	Relative velocity on face	Boundary 2	
spf.umxTn_there_ap7	src2dst_ap7(spf.upwind_helpx)*spf.nxmesh+src2dst_ap7(spf.upwind_helpy)*spf.nymesh+src2dst_ap7(spf.upwind_helpz)*spf.nzmesh	m/s	Relative velocity on face	Boundary 40	
spf.upwind_ns_ap7	spf.rhoFace_ap7*spf.umxTnFace_ap7*(spf.ujump_ap7x*test(spf.u_here_ap7x)+spf.ujump_ap7y*test(spf.u_here_ap7y)+spf.ujump_ap7z*test(spf.u_here_ap7z))/spf.epsilon_p^2	W/m^2	Upwind term	Boundary 2	
spf.upwind_ns_ap7	spf.rhoFace_ap7*spf.umxTnFace_ap7*(spf.ujump_ap7x*test(spf.u_here_ap7x)+spf.ujump_ap7y*test(spf.u_here_ap7y)+spf.ujump_ap7z*test(spf.u_here_ap7z))/spf.epsilon_p^2	W/m^2	Upwind term	Boundary 40	
spf.upwindCont_ap7	0.5*spf.contCoeffFace_ap7*(spf.ujump_ap7x*spf.nxmesh+spf.ujump_ap7y*spf.nymesh+spf.ujump_ap7z*spf.nzmesh)*test(spf.p_h	$kg^2/(m^3 \cdot s^3)$	Upwind term for continuity equation	Boundary 2	

Name	Expression	Unit	Description	Selection	Details
	ere_ap7)				
spf.upwindCont_ap7	0.5*spf.contCoeffFace_ap7*(spf.ujump_ap7x*spf.nxmesh+spf.ujump_ap7y*spf.nymesh+spf.ujump_ap7z*spf.nzmesh)*test(spf.p_here_ap7)	$kg^2/(m^3\cdot s^3)$	Upwind term for continuity equation	Boundary 40	
spf.p_there_ap7	dst2src_ap7(p2)	Pa	Pressure	Boundary 2	
spf.p_there_ap7	src2dst_ap7(p2)	Pa	Pressure	Boundary 40	
spf.pJump_ap7	spf.p_here_ap7-spf.p_there_ap7	Pa	Pressure jump	Boundary 2	
spf.pJump_ap7	spf.p_here_ap7-spf.p_there_ap7	Pa	Pressure jump	Boundary 40	
spf.pFace_ap7	0.5*(spf.p_here_ap7+spf.p_there_ap7)	Pa	Pressure face value	Boundary 2	
spf.pFace_ap7	0.5*(spf.p_here_ap7+spf.p_there_ap7)	Pa	Pressure face value	Boundary 40	
spf.consFlux_ap7	-spf.pFace_ap7*(test(spf.u_here_ap7x)*spf.nxmesh+test(spf.u_here_ap7y)*spf.nymesh+test(spf.u_here_ap7z)*spf.nzmesh)	W/m^2	Conservative flux	Boundary 2	+ operation
spf.consFlux_ap7	-spf.pFace_ap7*(test(spf.u_here_ap7x)*spf.nxmesh+test(spf.u_here_ap7y)*spf.nymesh+test(spf.u_here_ap7z)*spf.nzmesh)	W/m^2	Conservative flux	Boundary 40	+ operation
spf.kjump_ap7	k2-dst2src_ap7(k2)	m^2/s^2		Boundary 2	
spf.kjump_ap7	k2-src2dst_ap7(k2)	m^2/s^2		Boundary 40	
spf.Dk_ap7	spf.mu_here_ap7+spf.muT_here_ap7/spf.sigmak	Pa·s		Boundary 2	
spf.Dk_ap7	spf.mu_here_ap7+spf.muT_here_ap7/spf.sigmak	Pa·s		Boundary 40	
spf.gammak_here_ap7x	spf.Dk_ap7*k2x	W/m^2		Boundary 2	

Name	Expression	Unit	Description	Selection	Details
spf.gammak_here_ap7y	spf.Dk_ap7*k2y	W/m²		Boundary 2	
spf.gammak_here_ap7z	spf.Dk_ap7*k2z	W/m²		Boundary 2	
spf.gammak_here_ap7x	spf.Dk_ap7*k2x	W/m²		Boundary 40	
spf.gammak_here_ap7y	spf.Dk_ap7*k2y	W/m²		Boundary 40	
spf.gammak_here_ap7z	spf.Dk_ap7*k2z	W/m²		Boundary 40	
spf.gammak_there_ap7x	src2dst_ap7(spf.Dk_ap7*k2x)	W/m²		Boundary 40	
spf.gammak_there_ap7y	src2dst_ap7(spf.Dk_ap7*k2y)	W/m²		Boundary 40	
spf.gammak_there_ap7z	src2dst_ap7(spf.Dk_ap7*k2z)	W/m²		Boundary 40	
spf.gammak_there_ap7x	dst2src_ap7(spf.Dk_ap7*k2x)	W/m²		Boundary 2	
spf.gammak_there_ap7y	dst2src_ap7(spf.Dk_ap7*k2y)	W/m²		Boundary 2	
spf.gammak_there_ap7z	dst2src_ap7(spf.Dk_ap7*k2z)	W/m²		Boundary 2	
spf.gammakn_av_ap7	0.5*((spf.gammak_here_ap7x+spf.gammak_there_ap7x)*spf.nxmesh+(spf.gammak_here_ap7y+spf.gammak_there_ap7y)*spf.nymesh+(spf.gammak_here_ap7z+spf.gammak_there_ap7z)*spf.nzmesh)*test(k2)	kg·m²/s⁵		Boundary 2	
spf.gammakn_av_ap7	0.5*((spf.gammak_here_ap7x+spf.gammak_there_ap7x)*spf.nxmesh+(spf.gammak_here_ap7y+spf.gammak_there_ap7y)*spf.nymesh+(spf.gammak_here_ap7z+spf.gammak_there_ap7z)*spf.nzmesh)*test(k2)	kg·m²/s⁵		Boundary 40	
spf.gammakn_av_t	0.5*spf.Dk_ap7*(test(	kg·m²/s⁵		Boundary 2	

Name	Expression	Unit	Description	Selection	Details
est_ap7	k2x)*spf.nxmesh+test(k2y)*spf.nymesh+test(k2z)*spf.nzmesh)*spf.kjump_ap7				
spf.gammakn_av_test_ap7	0.5*spf.Dk_ap7*(test(k2x)*spf.nxmesh+test(k2y)*spf.nymesh+test(k2z)*spf.nzmesh)*spf.kjump_ap7	kg·m²/s⁵		Boundary 40	
spf.c_here_k_ap7	18*nojac(spf.Dk_ap7)*spf.meshVol_ap7/spf.meshVolInt_ap7	Pa·s/m		Boundary 2	
spf.c_here_k_ap7	18*nojac(spf.Dk_ap7)*spf.meshVol_ap7/spf.meshVolInt_ap7	Pa·s/m		Boundary 40	
spf.sigma_dg_k_ap7	spf.c_here_k_ap7+dst2src_ap7(spf.c_here_k_ap7)	Pa·s/m		Boundary 2	
spf.sigma_dg_k_ap7	spf.c_here_k_ap7+src2dst_ap7(spf.c_here_k_ap7)	Pa·s/m		Boundary 40	
spf.upwind_k_ap7	spf.rhoFace_ap7*spf.umxTnFace_ap7*spf.kjump_ap7*test(k2)	kg·m²/s⁵	Upwind term	Boundary 2	
spf.upwind_k_ap7	spf.rhoFace_ap7*spf.umxTnFace_ap7*spf.kjump_ap7*test(k2)	kg·m²/s⁵	Upwind term	Boundary 40	
spf.epjump_ap7	ep2-dst2src_ap7(ep2)	m²/s²		Boundary 2	
spf.epjump_ap7	ep2-src2dst_ap7(ep2)	m²/s²		Boundary 40	
spf.Dep_ap7	spf.mu_here_ap7+spf.muT_here_ap7/spf.sigmaeps	Pa·s		Boundary 2	
spf.Dep_ap7	spf.mu_here_ap7+spf.muT_here_ap7/spf.sigmaeps	Pa·s		Boundary 40	
spf.gammaep_here_ap7x	spf.Dep_ap7*ep2x	kg/s⁴		Boundary 2	
spf.gammaep_here_ap7y	spf.Dep_ap7*ep2y	kg/s⁴		Boundary 2	
spf.gammaep_here_ap7z	spf.Dep_ap7*ep2z	kg/s⁴		Boundary 2	
spf.gammaep_her	spf.Dep_ap7*ep2x	kg/s⁴		Boundary 40	

Name	Expression	Unit	Description	Selection	Details
e_ap7x					
spf.gammaep_here_ap7y	spf.Dep_ap7*ep2y	kg/s⁴		Boundary 40	
spf.gammaep_here_ap7z	spf.Dep_ap7*ep2z	kg/s⁴		Boundary 40	
spf.gammaep_there_ap7x	src2dst_ap7(spf.Dep_ap7*ep2x)	kg/s⁴		Boundary 40	
spf.gammaep_there_ap7y	src2dst_ap7(spf.Dep_ap7*ep2y)	kg/s⁴		Boundary 40	
spf.gammaep_there_ap7z	src2dst_ap7(spf.Dep_ap7*ep2z)	kg/s⁴		Boundary 40	
spf.gammaep_there_ap7x	dst2src_ap7(spf.Dep_ap7*ep2x)	kg/s⁴		Boundary 2	
spf.gammaep_there_ap7y	dst2src_ap7(spf.Dep_ap7*ep2y)	kg/s⁴		Boundary 2	
spf.gammaep_there_ap7z	dst2src_ap7(spf.Dep_ap7*ep2z)	kg/s⁴		Boundary 2	
spf.gammaepn_av_ap7	0.5*((spf.gammaep_here_ap7x+spf.gammaep_there_ap7x)*spf.nxmesh+(spf.gammaep_here_ap7y+spf.gammaep_there_ap7y)*spf.nymesh+(spf.gammaep_here_ap7z+spf.gammaep_there_ap7z)*spf.nzmesh)*test(ep2)	kg·m²/s⁷		Boundary 2	
spf.gammaepn_av_ap7	0.5*((spf.gammaep_here_ap7x+spf.gammaep_there_ap7x)*spf.nxmesh+(spf.gammaep_here_ap7y+spf.gammaep_there_ap7y)*spf.nymesh+(spf.gammaep_here_ap7z+spf.gammaep_there_ap7z)*spf.nzmesh)*test(ep2)	kg·m²/s⁷		Boundary 40	
spf.gammaepn_av_test_ap7	0.5*spf.Dep_ap7*(test(ep2x)*spf.nxmesh+test(ep2y)*spf.nymesh+test(ep2z)*spf.nzmesh)*spf.epjump_ap7	kg·m²/s⁶		Boundary 2	

Name	Expression	Unit	Description	Selection	Details
spf.gammaepn_av_test_ap7	0.5*spf.Dep_ap7*(test(ep2x)*spf.nxmesh+test(ep2y)*spf.nymesh+test(ep2z)*spf.nzmesh)*spf.epjump_ap7	kg·m²/s⁶		Boundary 40	
spf.c_here_ep_ap7	18*nojac(spf.Dep_ap7)*spf.meshVol_ap7/spf.meshVolInt_ap7	Pa·s/m		Boundary 2	
spf.c_here_ep_ap7	18*nojac(spf.Dep_ap7)*spf.meshVol_ap7/spf.meshVolInt_ap7	Pa·s/m		Boundary 40	
spf.sigma_dg_ep_ap7	spf.c_here_ep_ap7+dst2src_ap7(spf.c_here_ep_ap7)	Pa·s/m		Boundary 2	
spf.sigma_dg_ep_ap7	spf.c_here_ep_ap7+src2dst_ap7(spf.c_here_ep_ap7)	Pa·s/m		Boundary 40	
spf.upwind_ep_ap7	spf.rhoFace_ap7*spf.umxTnFace_ap7*spf.epjump_ap7*test(ep2)	kg·m²/s⁶	Upwind term	Boundary 2	
spf.upwind_ep_ap7	spf.rhoFace_ap7*spf.umxTnFace_ap7*spf.epjump_ap7*test(ep2)	kg·m²/s⁶	Upwind term	Boundary 40	

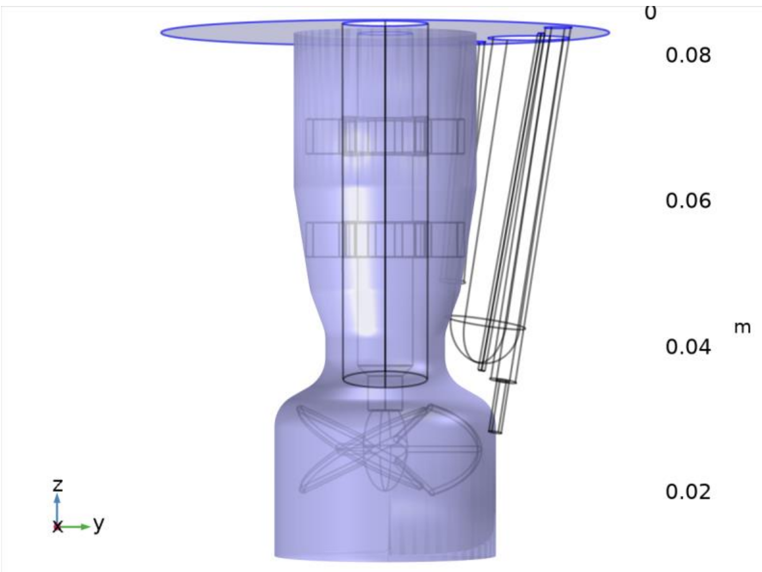
Weak expressions

Weak expression	Integration order	Integration frame	Selection
if(incontact_ap7,spf.KStressn_av_ap7x*test(spf.u_here_ap7x)+spf.KStressn_av_ap7y*test(spf.u_here_ap7y)+spf.KStressn_av_ap7z*test(spf.u_here_ap7z),0)	6	Spatial	Boundary 2
if(incontact_ap7,0.5*((spf.K_stress_tensor_testxx*spf.nxmesh+spf.K_stress_tensor_testxy*spf.nymesh+spf.K_stress_tensor_testxz*spf.nzmesh)*spf.ujump_ap7x+(spf.K_stress_tensor_testyx*spf.nxmesh+spf.K_stress_tensor_testyy*spf.nymesh+spf.K_stress_tensor_testyz*spf.nzmesh)*spf.ujump_ap7y+(spf.K_stress_tensor_testzx*spf.nxmesh+spf.K_stress_tensor_testzy*spf.nymesh+spf.K_stress_tensor_testzz*spf.nzmesh)*spf.ujump_ap7z),0)	6	Spatial	Boundary 2
if(incontact_ap7,spf.sigma_dg_ns_ap	6	Spatial	Boundary 2

Weak expression	Integration order	Integration frame	Selection
7*(-spf.ujump_ap7x*test(spf.u_here_ap7x)-spf.ujump_ap7y*test(spf.u_here_ap7y)-spf.ujump_ap7z*test(spf.u_here_ap7z)),0)			
if(incontact_ap7,spf.upwind_ns_ap7+spf.upwindCont_ap7+spf.consFlux_ap7,0)	6	Spatial	Boundary 2
if(incontact_ap7,spf.KStressn_av_ap7x*test(spf.u_here_ap7x)+spf.KStressn_av_ap7y*test(spf.u_here_ap7y)+spf.KStressn_av_ap7z*test(spf.u_here_ap7z),0)	6	Spatial	Boundary 40
if(incontact_ap7,0.5*((spf.K_stress_tensor_testxx*spf.nxmesh+spf.K_stress_tensor_testxy*spf.nymesh+spf.K_stress_tensor_testxz*spf.nzmesh)*spf.ujump_ap7x+(spf.K_stress_tensor_testyx*spf.nxmesh+spf.K_stress_tensor_testyy*spf.nymesh+spf.K_stress_tensor_testyz*spf.nzmesh)*spf.ujump_ap7y+(spf.K_stress_tensor_testzx*spf.nxmesh+spf.K_stress_tensor_testzy*spf.nymesh+spf.K_stress_tensor_testzz*spf.nzmesh)*spf.ujump_ap7z),0)	6	Spatial	Boundary 40
if(incontact_ap7,spf.sigma_dg_ns_ap7*(-spf.ujump_ap7x*test(spf.u_here_ap7x)-spf.ujump_ap7y*test(spf.u_here_ap7y)-spf.ujump_ap7z*test(spf.u_here_ap7z)),0)	6	Spatial	Boundary 40
if(incontact_ap7,spf.upwind_ns_ap7+spf.upwindCont_ap7+spf.consFlux_ap7,0)	6	Spatial	Boundary 40
if(incontact_ap7,spf.gammakn_av_ap7+spf.gammakn_av_test_ap7-spf.sigma_dg_k_ap7*spf.kjump_ap7*test(k2)+spf.upwind_k_ap7,0)	6	Spatial	Boundary 2
if(incontact_ap7,spf.gammakn_av_ap7+spf.gammakn_av_test_ap7-spf.sigma_dg_k_ap7*spf.kjump_ap7*	6	Spatial	Boundary 40

Weak expression	Integration order	Integration frame	Selection
test(k2)+spf.upwind_k_ap7,0)			
if(incontact_ap7,spf.gammaepn_av_ap7+spf.gammaepn_av_test_ap7-spf.sigma_dg_ep_ap7*spf.epjump_ap7*test(ep2)+spf.upwind_ep_ap7,0)	6	Spatial	Boundary 2
if(incontact_ap7,spf.gammaepn_av_ap7+spf.gammaepn_av_test_ap7-spf.sigma_dg_ep_ap7*spf.epjump_ap7*test(ep2)+spf.upwind_ep_ap7,0)	6	Spatial	Boundary 40

Wall 1



Wall 1

SELECTION

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

EQUATIONS

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

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

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

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

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_ap7,1,0)		Help variable	Boundary 40	
spf.hasWF	if(!incontact_ap7,1,0)		Help variable	Boundary 2	
spf.k_nn	if(!incontact_ap7,max(k2,0),0)	m^2/s^2	Regularized turbulent kinetic energy	Boundary 40	
spf.k_nn	if(!incontact_ap7,max(k2,0),0)	m^2/s^2	Regularized turbulent kinetic energy	Boundary 2	
spf.ubndx	if(!incontact_ap7,spf.utrx+spf.usx,0)	m/s	Velocity at boundary, x component	Boundary 40	
spf.ubndy	if(!incontact_ap7,spf.utry+spf.usy,0)	m/s	Velocity at boundary, y component	Boundary 40	
spf.ubndz	if(!incontact_ap7,spf.utrz+spf.usz,0)	m/s	Velocity at boundary, z component	Boundary 40	
spf.ubndx	if(!incontact_ap7,spf.utrx+spf.usx,0)	m/s	Velocity at boundary, x component	Boundary 2	
spf.ubndy	if(!incontact_ap7,spf.utry+spf.usy,0)	m/s	Velocity at boundary, y component	Boundary 2	
spf.ubndz	if(!incontact_ap7,spf.utrz+spf.usz,0)	m/s	Velocity at boundary, z component	Boundary 2	
spf.usx	0	m/s	Velocity of sliding wall, x component	Boundary 40	
spf.usy	0	m/s	Velocity of	Boundary 40	

Name	Expression	Unit	Description	Selection	Details
			sliding wall, y component		
spf.usz	0	m/s	Velocity of sliding wall, z component	Boundary 40	
spf.usx	0	m/s	Velocity of sliding wall, x component	Boundary 2	
spf.usy	0	m/s	Velocity of sliding wall, y component	Boundary 2	
spf.usz	0	m/s	Velocity of sliding wall, z component	Boundary 2	
spf.utrx	if(!incontact_ap7,d(x,TIME),0)	m/s	Velocity of moving wall, x component	Boundary 40	
spf.utry	if(!incontact_ap7,d(y,TIME),0)	m/s	Velocity of moving wall, y component	Boundary 40	
spf.utrz	if(!incontact_ap7,d(z,TIME),0)	m/s	Velocity of moving wall, z component	Boundary 40	
spf.utrx	0	m/s	Velocity of moving wall, x component	Boundary 2	
spf.utry	0	m/s	Velocity of moving wall, y component	Boundary 2	
spf.utrz	0	m/s	Velocity of moving wall, z component	Boundary 2	
spf.uLeakagex	0	m/s	Leakage velocity, x component	Boundary 40	+ operation
spf.uLeakagey	0	m/s	Leakage velocity, y component	Boundary 40	+ operation
spf.uLeakagez	0	m/s	Leakage velocity, z component	Boundary 40	+ operation
spf.uLeakagex	0	m/s	Leakage velocity, x component	Boundary 2	+ operation
spf.uLeakagey	0	m/s	Leakage velocity, y component	Boundary 2	+ operation

Name	Expression	Unit	Description	Selection	Details
spf.uLeakagez	0	m/s	Leakage velocity, z component	Boundary 2	+ operation
spf.noSlipWall	if(!incontact_ap7,1,0)	1	Help variable	Boundary 40	
spf.noSlipWall	if(!incontact_ap7,1,0)	1	Help variable	Boundary 2	
spf.un_here	if(!incontact_ap7,u*nojac(spf.nxmesh)+v*nojac(spf.nymesh)+w*nojac(spf.nzmesh),0)	m/s	Intermediate variable	Boundary 40	
spf.un_here	if(!incontact_ap7,u*nojac(spf.nxmesh)+v*nojac(spf.nymesh)+w*nojac(spf.nzmesh),0)	m/s	Intermediate variable	Boundary 2	
spf.u_herex	if(!incontact_ap7,spf.un_here*nojac(spf.nxmesh),0)	m/s	Intermediate variable, x component	Boundary 40	
spf.u_herey	if(!incontact_ap7,spf.un_here*nojac(spf.nymesh),0)	m/s	Intermediate variable, y component	Boundary 40	
spf.u_herez	if(!incontact_ap7,spf.un_here*nojac(spf.nzmesh),0)	m/s	Intermediate variable, z component	Boundary 40	
spf.u_herex	if(!incontact_ap7,spf.un_here*nojac(spf.nxmesh),0)	m/s	Intermediate variable, x component	Boundary 2	
spf.u_herey	if(!incontact_ap7,spf.un_here*nojac(spf.nymesh),0)	m/s	Intermediate variable, y component	Boundary 2	
spf.u_herez	if(!incontact_ap7,spf.un_here*nojac(spf.nzmesh),0)	m/s	Intermediate variable, z component	Boundary 2	
spf.un_there	if(!incontact_ap7,(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 40	
spf.un_there	if(!incontact_ap7,(spf.ubndx+spf.uLeakagex)*nojac(spf.nxmesh)+(spf.ubndy+spf.uLeakagey)*nojac(spf.nymesh)+	m/s	Intermediate variable	Boundary 2	

Name	Expression	Unit	Description	Selection	Details
	(spf.ubndz+spf.uLeakagez)*nojac(spf.nzmesh),0)				
spf.u_therex	if(!incontact_ap7,spf.un_there*nojac(spf.nxmesh),0)	m/s	Intermediate variable, x component	Boundary 40	
spf.u_therey	if(!incontact_ap7,spf.un_there*nojac(spf.nymesh),0)	m/s	Intermediate variable, y component	Boundary 40	
spf.u_therez	if(!incontact_ap7,spf.un_there*nojac(spf.nzmesh),0)	m/s	Intermediate variable, z component	Boundary 40	
spf.u_therex	if(!incontact_ap7,spf.un_there*nojac(spf.nxmesh),0)	m/s	Intermediate variable, x component	Boundary 2	
spf.u_therey	if(!incontact_ap7,spf.un_there*nojac(spf.nymesh),0)	m/s	Intermediate variable, y component	Boundary 2	
spf.u_therez	if(!incontact_ap7,spf.un_there*nojac(spf.nzmesh),0)	m/s	Intermediate variable, z component	Boundary 2	
spf.unJump	if(!incontact_ap7,spf.un_here-spf.un_there,0)	m/s	Jump in normal velocity	Boundary 40	
spf.unJump	if(!incontact_ap7,spf.un_here-spf.un_there,0)	m/s	Jump in normal velocity	Boundary 2	
spf.KStressn_avx	if(!incontact_ap7,spf.K_stress_tensorxx*spf.nxmesh+spf.K_stress_tensorxy*spf.nymesh+spf.K_stress_tensorxz*spf.nzmesh,0)	N/m^2	Average viscous stress, x component	Boundary 40	
spf.KStressn_avy	if(!incontact_ap7,spf.K_stress_tensoryx*spf.nxmesh+spf.K_stress_tensoryy*spf.nymesh+spf.K_stress_tensoryz*spf.nzmesh,0)	N/m^2	Average viscous stress, y component	Boundary 40	
spf.KStressn_avz	if(!incontact_ap7,spf.K_stress_tensorzx*spf.nxmesh+spf.K_stress_tensorzy*spf.nymesh+spf.K_stress_tensorzz*spf.nzmesh,0)	N/m^2	Average viscous stress, z component	Boundary 40	

Name	Expression	Unit	Description	Selection	Details
spf.KStressn_avx	if(!incontact_ap7,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 2	
spf.KStressn_avy	if(!incontact_ap7,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 2	
spf.KStressn_avz	if(!incontact_ap7,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 2	
spf.KStressTestn_avx	if(!incontact_ap7,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 40	
spf.KStressTestn_avy	if(!incontact_ap7,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 40	
spf.KStressTestn_avz	if(!incontact_ap7,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 40	
spf.KStressTestn_avx	if(!incontact_ap7,spf.K_stress_tensor_testxx*spf.nxmesh+spf.K_stress_tensor_testxy*spf.nymesh+spf.K_stress_tensor_testxz*spf.nzmesh,	N/m²	Average viscous stress, x component	Boundary 2	

Name	Expression	Unit	Description	Selection	Details
	0)				
spf.KStressTestn_avy	if(!incontact_ap7,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 2	
spf.KStressTestn_avz	if(!incontact_ap7,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 2	
spf.ujumpx	if(!incontact_ap7,spf.u_herex-spf.u_therex,0)	m/s	Velocity jump, x component	Boundary 40	
spf.ujumpy	if(!incontact_ap7,spf.u_herey-spf.u_therey,0)	m/s	Velocity jump, y component	Boundary 40	
spf.ujumpz	if(!incontact_ap7,spf.u_herez-spf.u_therez,0)	m/s	Velocity jump, z component	Boundary 40	
spf.ujumpx	if(!incontact_ap7,spf.u_herex-spf.u_therex,0)	m/s	Velocity jump, x component	Boundary 2	
spf.ujumpy	if(!incontact_ap7,spf.u_herey-spf.u_therey,0)	m/s	Velocity jump, y component	Boundary 2	
spf.ujumpz	if(!incontact_ap7,spf.u_herez-spf.u_therez,0)	m/s	Velocity jump, z component	Boundary 2	
spf.contCoeffFace	if(!incontact_ap7,down(spf.contCoeff),0)	kg/m³	Help variable	Boundary 40	
spf.contCoeffFace	if(!incontact_ap7,down(spf.contCoeff),0)	kg/m³	Help variable	Boundary 2	
spf.rhoFace	if(!incontact_ap7,down(spf.rho),0)	kg/m³	Density face value	Boundary 40	
spf.rhoFace	if(!incontact_ap7,down(spf.rho),0)	kg/m³	Density face value	Boundary 2	
spf.c_here	if(!incontact_ap7,36*nojac(down(spf.mu+spf.muT)/down(1))*spf.meshVol/spf.meshVolInt,0)	Pa·s/m	Intermediate variable	Boundary 40	
spf.c_here	if(!incontact_ap7,36*nojac(down(spf.mu+spf.muT)/down(1))*spf.m	Pa·s/m	Intermediate variable	Boundary 2	

Name	Expression	Unit	Description	Selection	Details
	eshVol/spf.meshVolInt,0)				
spf.meshVol	if(!incontact_ap7,meshvol_spatial,if(!incontact_ap7,meshvol,0))	m²		Boundary 40	
spf.meshVol	if(!incontact_ap7,meshvol_spatial,if(!incontact_ap7,meshvol,0))	m²		Boundary 2	
spf.meshVolInt	if(!incontact_ap7,down(meshvol_spatial),if(!incontact_ap7,down(meshvol),0))	m³	Volume of interior mesh element	Boundary 40	
spf.meshVolInt	if(!incontact_ap7,down(meshvol_spatial),if(!incontact_ap7,down(meshvol),0))	m³	Volume of interior mesh element	Boundary 2	
spf.sigma_dg_ns	if(!incontact_ap7,4*spf.c_here,0)	Pa·s/m		Boundary 40	
spf.sigma_dg_ns	if(!incontact_ap7,4*spf.c_here,0)	Pa·s/m		Boundary 2	
spf.umxTnFace	if(!incontact_ap7,(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 40	
spf.umxTnFace	if(!incontact_ap7,(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 2	
spf.upwind_ns	if(!incontact_ap7,spf.rhoFace*spf.umxTnFace*spf.unJump*test(spf.un_here)/down(1)^2,0)	W/m²	Upwind term	Boundary 40	

Name	Expression	Unit	Description	Selection	Details
spf.upwind_ns	if(!incontact_ap7,spf.rhoFace*spf.umxTnFace*spf.unJump*test(spf.un_here)/down(1)^2,0)	W/m²	Upwind term	Boundary 2	
spf.upwindCont	if(!incontact_ap7,spf.contCoeffFace*spf.unJump*test(p2),0)	$kg^2/(m^3 \cdot s^3)$	Upwind term for continuity equation	Boundary 40	
spf.upwindCont	if(!incontact_ap7,spf.contCoeffFace*spf.unJump*test(p2),0)	$kg^2/(m^3 \cdot s^3)$	Upwind term for continuity equation	Boundary 2	
spf.pFace	if(!incontact_ap7,p2,0)	Pa	Pressure face value	Boundary 40	
spf.pFace	if(!incontact_ap7,p2,0)	Pa	Pressure face value	Boundary 2	
spf.consFlux	if(!incontact_ap7,-spf.pFace*test(spf.un_here),0)	W/m²	Conservative flux	Boundary 40	+ operation
spf.consFlux	if(!incontact_ap7,-spf.pFace*test(spf.un_here),0)	W/m²	Conservative flux	Boundary 2	+ operation
spf.d_w_plus	if(!incontact_ap7,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 40	
spf.d_w_plus	if(!incontact_ap7,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 2	
spf.uPlus	if(!incontact_ap7,log(spf.d_w_plus)/spf.kappav+spf.B,0)	1	Tangential velocity in viscous units	Boundary 40	+ operation
spf.uPlus	if(!incontact_ap7,log(spf.d_w_plus)/spf.kappav+spf.B,0)	1	Tangential velocity in viscous units	Boundary 2	+ operation
spf.mixLParam	if(!incontact_ap7,spf.C_mu,0)	1	Intermediate variable	Boundary 40	
spf.mixLParam	if(!incontact_ap7,spf.C	1	Intermediate	Boundary 2	

Name	Expression	Unit	Description	Selection	Details
	_mu,0)		variable		
spf.ep_w	if(!incontact_ap7,spf.mixLParam*spf.k_nn^2*nojac(down(spf.rho))/(spf.kappav*spf.d_w_plus*nojac(down(spf.mu))),0)	m^2/s^3	Turbulent dissipation rate, (wall adjacent cells)	Boundary 40	
spf.ep_w	if(!incontact_ap7,spf.mixLParam*spf.k_nn^2*nojac(down(spf.rho))/(spf.kappav*spf.d_w_plus*nojac(down(spf.mu))),0)	m^2/s^3	Turbulent dissipation rate, (wall adjacent cells)	Boundary 2	
spf.u_tau	if(!incontact_ap7,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 40	
spf.u_tau	if(!incontact_ap7,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 2	
spf.u_tangx	if(!incontact_ap7,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 40	
spf.u_tangy	if(!incontact_ap7,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 40	
spf.u_tangz	if(!incontact_ap7,w-spf.ubndz-	m/s	Velocity field, z component	Boundary 40	

Name	Expression	Unit	Description	Selection	Details
	spf.nzmesh*((u-spf.ubndx)*spf.nxmesh+(v-spf.ubndy)*spf.nymesh+(w-spf.ubndz)*spf.nzmesh),0)				
spf.u_tangx	if(!incontact_ap7,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 2	
spf.u_tangy	if(!incontact_ap7,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 2	
spf.u_tangz	if(!incontact_ap7,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 2	
spf.delta_w	if(!incontact_ap7,spf.d_w_plus*down(spf.mu)/(down(spf.rho)*max(spf.u_tau,sqrt(eps))),0)	m	Wall lift-off	Boundary 40	
spf.delta_w	if(!incontact_ap7,spf.d_w_plus*down(spf.mu)/(down(spf.rho)*max(spf.u_tau,sqrt(eps))),0)	m	Wall lift-off	Boundary 2	
spf.uStar	if(!incontact_ap7,spf.u_tau,0)	m/s	Friction velocity	Boundary 40	
spf.uStar	if(!incontact_ap7,spf.u_	m/s	Friction velocity	Boundary 2	

Name	Expression	Unit	Description	Selection	Details
	tau,0)				
spf.Delta_wPlus	if(!incontact_ap7,spf.d_w_plus,0)	1	Wall resolution in viscous units	Boundary 40	
spf.Delta_wPlus	if(!incontact_ap7,spf.d_w_plus,0)	1	Wall resolution in viscous units	Boundary 2	
spf.WRHeightExpr	if(!incontact_ap7,-11.06+spf.d_w_plus,0)	1	Wall resolution height expression	Boundary 40	
spf.WRHeightExpr	if(!incontact_ap7,-11.06+spf.d_w_plus,0)	1	Wall resolution height expression	Boundary 2	

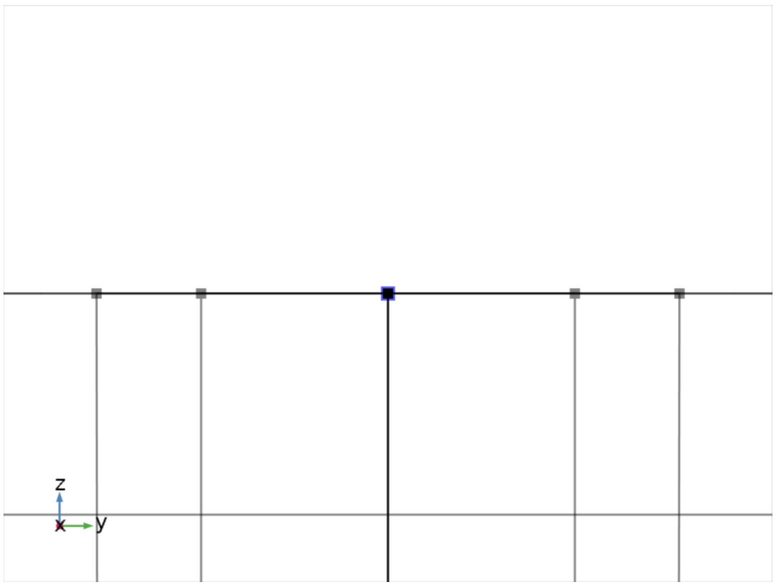
Weak expressions

Weak expression	Integration order	Integration frame	Selection
if(!incontact_ap7,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 40
if(!incontact_ap7,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 2
if(!incontact_ap7,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 40
if(!incontact_ap7,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 2

Constraints

Constraint	Constraint force	Shape function	Selection	Details
if(!incontact_ap7,-ep2+spf.ep_w,0)	if(!incontact_ap7,test(-ep2),0)	Lagrange (Linear)	Boundary 40	Elemental
if(!incontact_ap7,-ep2+spf.ep_w,0)	if(!incontact_ap7,test(-ep2),0)	Lagrange (Linear)	Boundary 2	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

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

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

Pressure constraint

SETTINGS

Description	Value
Pressure	0
Compensate for hydrostatic pressure	On

Variables

Name	Expression	Unit	Description	Selection

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

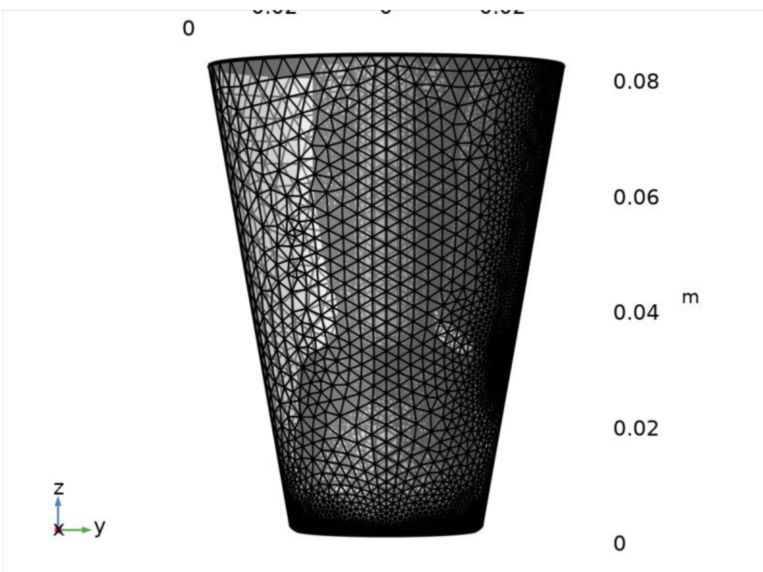
Constraints

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	0.01932
Average element quality	0.6647
Tetrahedron	1562119
Pyramid	6402
Prism	121636
Triangle	82260
Quad	80
Edge element	6192
Vertex element	359



Mesh 1

2.5.1 Size (size)

SETTINGS

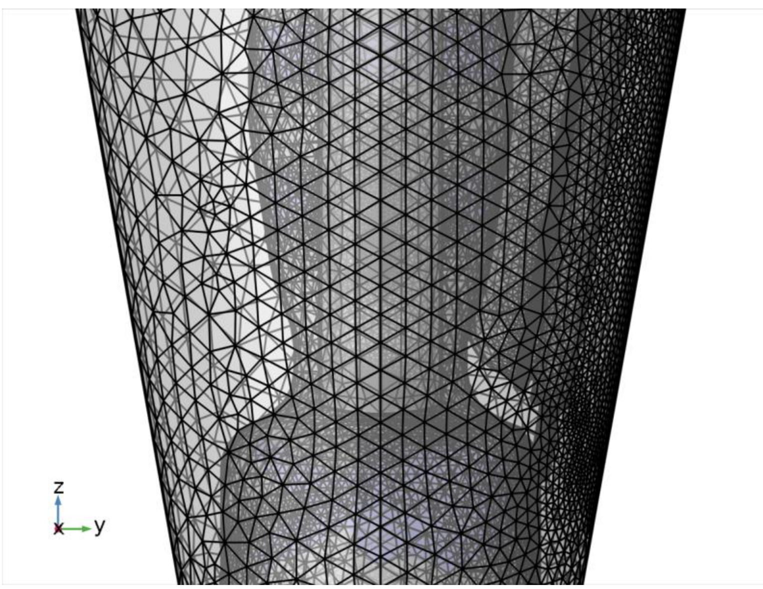
Description	Value

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	1.15
Custom element size	Custom

2.5.2 Rührer (size1)

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundaries 41–94, 103–109, 112–137, 143, 146, 150–212



Rührer

SETTINGS

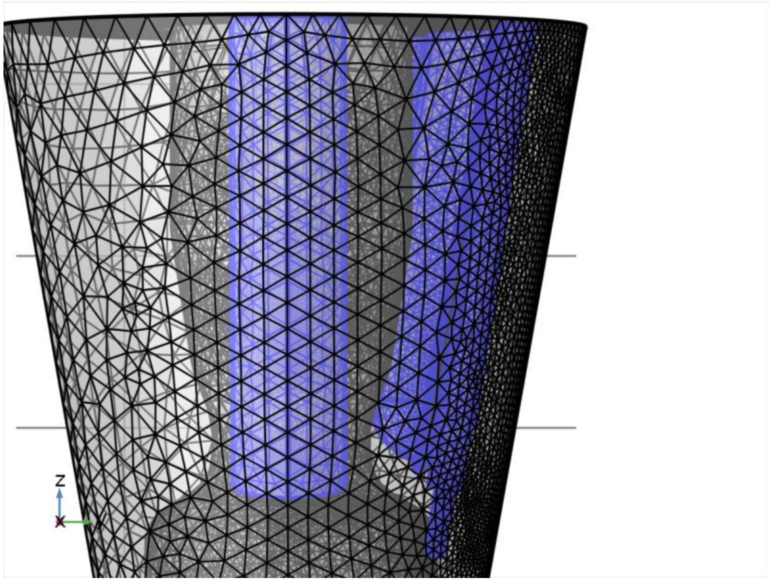
Description	Value
Calibrate for	Fluid dynamics
Maximum element size	3E-3
Minimum element size	mf2
Curvature factor	0.6
Resolution of narrow regions	0.7
Maximum element growth rate	1.2

Description	Value
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, 12–14, 16–18, 20–21, 23, 25–39, 95–102, 110–112, 138–142, 144–145, 147–149



Shaft+Sonden

SETTINGS

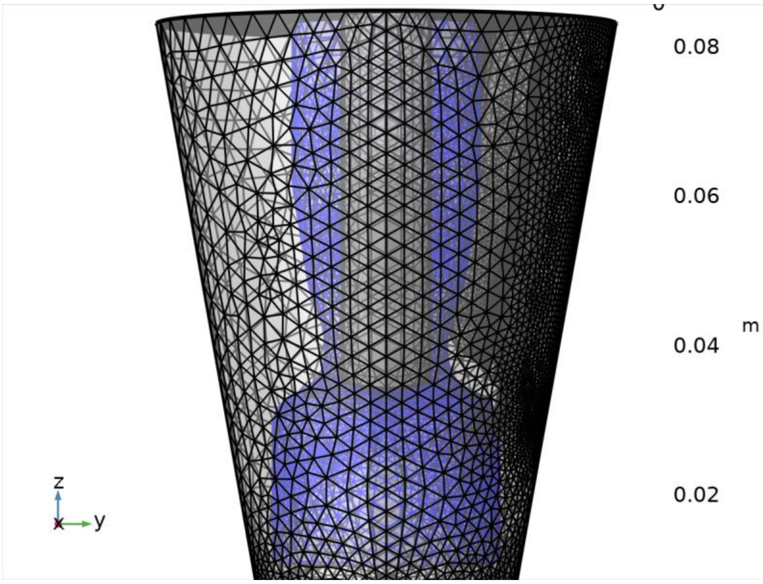
Description	Value
Calibrate for	Fluid dynamics
Maximum element size	0.003
Minimum element size	1E-5
Curvature factor	0.4
Resolution of narrow regions	0.7
Maximum element growth rate	1.2
Custom element size	Custom

2.5.4 Rotationsgebiet (size3)

SELECTION

Geometric entity level	Boundary

Selection	Geometry geom1: Dimension 2: Boundary 40



Rotationsgebiet

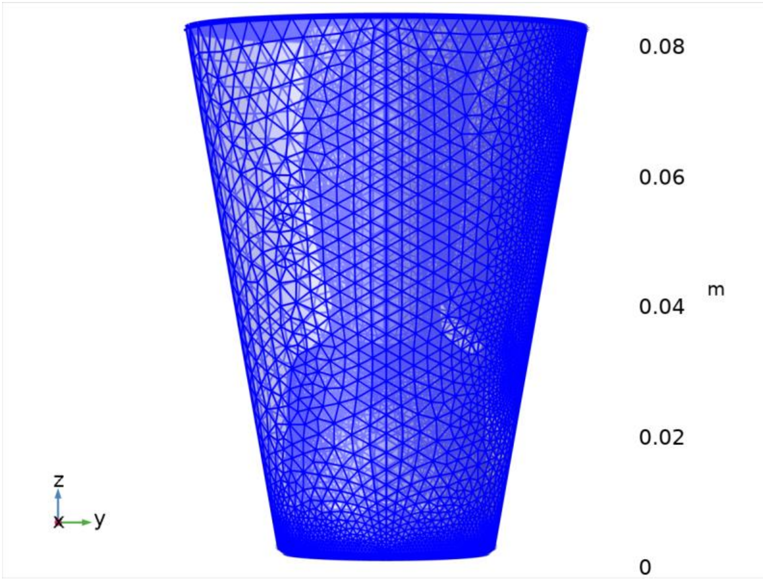
SETTINGS

Description	Value
Calibrate for	Fluid dynamics
Maximum element size	0.003
Minimum element size	mf2
Curvature factor	0.6
Resolution of narrow regions	0.7
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

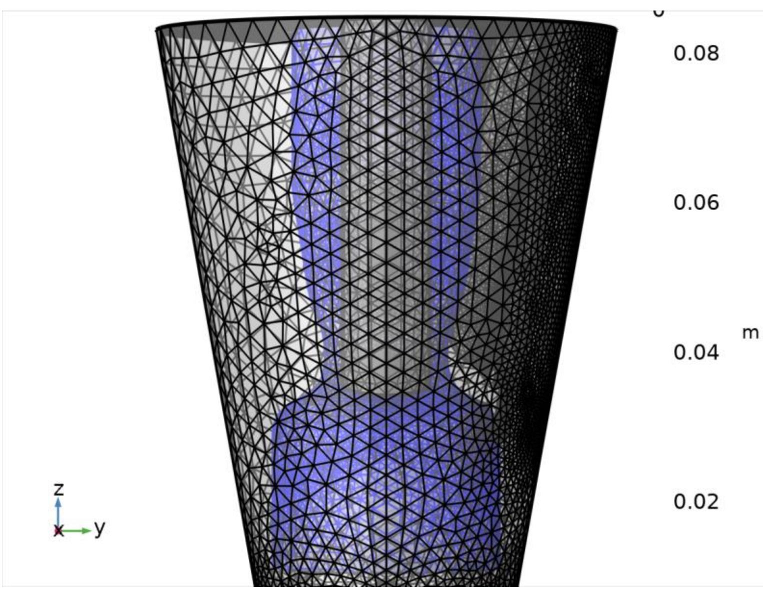


Corner Refinement 1

2.5.6 Free Tetrahedral 1 (ftet1)

SELECTION

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



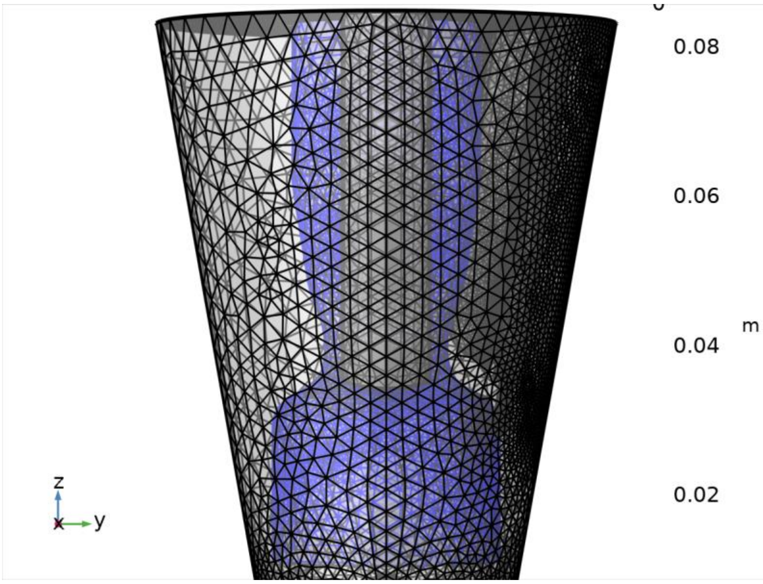
Free Tetrahedral 1

Size 1 (size1)

SELECTION

Geometric entity level	Domain

Selection	Geometry geom1: Dimension 3: Domain 2



Size 1

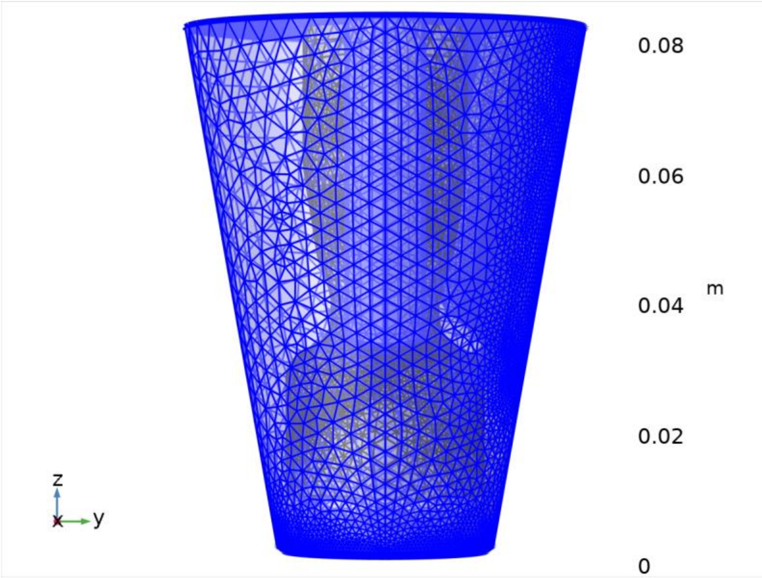
SETTINGS

Description	Value
Calibrate for	Fluid dynamics
Maximum element size	0.003
Minimum element size	mf1
Curvature factor	0.6
Resolution of narrow regions	0.7
Maximum element growth rate	1.2
Custom element size	Custom

2.5.7 Free Tetrahedral 2 (ftet2)

SELECTION

Geometric entity level	Domain
Selection	Remaining

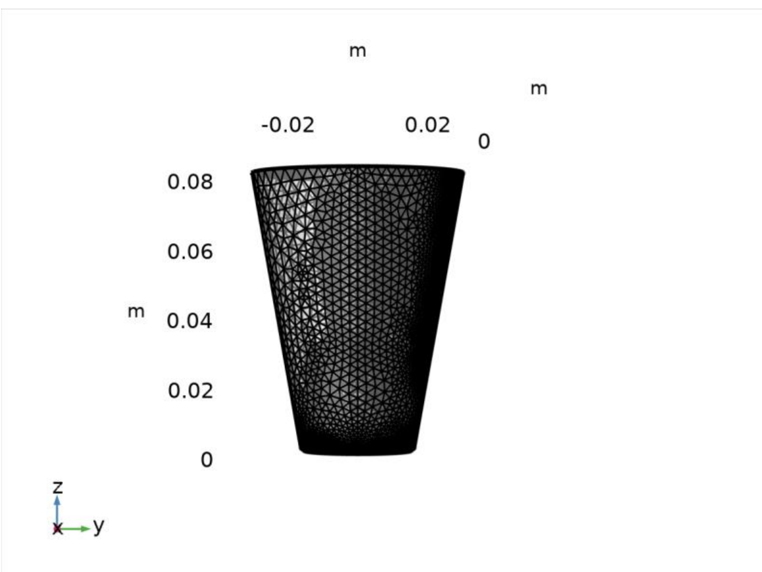


Free Tetrahedral 2

2.5.8 Boundary Layers 1 (bl1)

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1



Boundary Layers 1

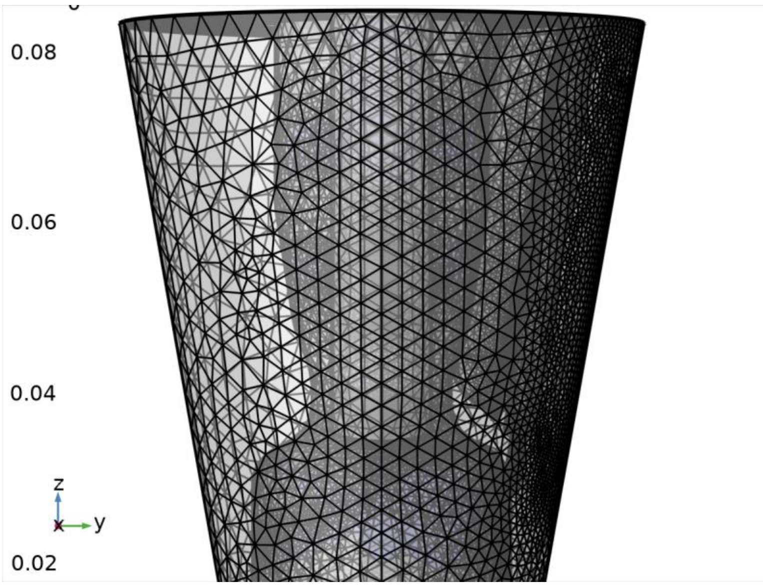
SETTINGS

Description	Value
Handling of sharp edges	Trimming

Boundary Layer Properties 1 (blp1)

SELECTION

Geometric entity level	Boundary
Selection	Geometry geom1: Dimension 2: Boundaries 41–212



Boundary Layer Properties 1

SETTINGS

Description	Value
Number of boundary layers	5
Thickness adjustment factor	2

3 Study 1

COMPUTATION INFORMATION

Computation time	32 h 55 min 40 s
CPU	Intel64 Family 6 Model 158 Stepping 9, 4 cores
Operating system	Windows 10

3.1 SWEEP GESCHWINDIGKEIT

Parameter name	Parameter value list	Parameter unit
f	range(50,50,600)	rpm

STUDY SETTINGS

Description	Value
Sweep type	All combinations
Parameter name	f
Unit	rpm

PARAMETERS

Parameter name	Parameter value list	Parameter unit
f	range(50,50,600)	rpm

3.2 SWEEP 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 23, 2021 11:41:58 AM.
Geometry shape order: Linear
Running on 2 x Intel(R) Xeon(R) CPU E5-2680 v4 at 2.40 GHz.
Using 2 sockets with 24 cores in total on g133.
Available memory: 128.55 GB.
Time: 5 s.
Physical memory: 1.21 GB
Virtual memory: 10.57 GB
Ended at Feb 23, 2021 11:42:03 AM.
----- 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(50,50,600)[rpm]

LOG

```
<---- Dependent Variables 1 in Study 1/Solution 1 (sol1) -----------------------
Started at Feb 23, 2021 11:42:03 AM.
Solution time: 1 s.
Physical memory: 2.09 GB
Virtual memory: 10.68 GB
Ended at Feb 23, 2021 11:42:04 AM.
----- 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

```
93, 4.3e+04
Pseudo time-stepping CFL-ratio:
0.29
Segregated solver iteration 98.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.23   0.5000000        0.23 2493 1241 1241 15403  0.00083    7e-05
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.065     5.9e+04   0.3500000       0.065 6095 3602 3602 19360  0.00065
     -
   2       0.048     4.7e+04   0.3500000       0.048 6096 3603 3603 19365  0.00086
     -
   3       0.037       4e+04   0.3500000       0.037 6097 3604 3604 19370  0.00071
     -
Solution error estimates for segregated groups
0.12, 0.054
Residual error estimates for segregated groups
86, 4e+04
Pseudo time-stepping CFL-ratio:
0.28
Segregated solver iteration 99.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.24   0.5000000        0.24 2495 1242 1242 15419  0.00075  6.8e-05
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.064     5.8e+04   0.3500000       0.064 6100 3605 3605 19378  0.00066
     -
   2       0.048     4.6e+04   0.3500000       0.048 6101 3606 3606 19383  0.00086
     -
   3       0.038     3.7e+04   0.3500000       0.038 6102 3607 3607 19388   0.0007
     -
Solution error estimates for segregated groups
0.12, 0.054
Residual error estimates for segregated groups
82, 3.7e+04
Pseudo time-stepping CFL-ratio:
0.28
Segregated solver iteration 100.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.23   0.5000000        0.23 2497 1243 1243 15435  0.00084  6.8e-05
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.063     5.7e+04   0.3500000       0.063 6105 3608 3608 19396  0.00068
     -
   2       0.048     4.4e+04   0.3500000       0.048 6106 3609 3609 19401  0.00085
     -
   3       0.039     3.5e+04   0.3500000       0.039 6107 3610 3610 19406  0.00071
     -
Solution error estimates for segregated groups
0.12, 0.055
```

```
Residual error estimates for segregated groups
80, 3.5e+04
Pseudo time-stepping CFL-ratio:
0.28
Segregated solver iteration 101.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.23   0.5000000        0.23 2499 1244 1244 15451  0.00095  8.6e-05
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.063     5.4e+04   0.3500000       0.063 6110 3611 3611 19414  0.00066
     -
   2       0.049     4.2e+04   0.3500000       0.049 6111 3612 3612 19419   0.0009
     -
   3       0.041     3.3e+04   0.3500000       0.041 6112 3613 3613 19424  0.00076
     -
Solution error estimates for segregated groups
0.11, 0.055
Residual error estimates for segregated groups
79, 3.3e+04
Pseudo time-stepping CFL-ratio:
0.28
Segregated solver iteration 102.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.26   0.5000000        0.26 2501 1245 1245 15467   0.0009  7.1e-05
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.066     5.2e+04   0.3500000       0.066 6115 3614 3614 19432  0.00065
     -
   2       0.053     4.1e+04   0.3500000       0.053 6116 3615 3615 19438  0.00048
     -
   3       0.044     3.3e+04   0.3500000       0.044 6117 3616 3616 19443  0.00084
     -
Solution error estimates for segregated groups
0.13, 0.056
Residual error estimates for segregated groups
1.5e+02, 3.3e+04
Pseudo time-stepping CFL-ratio:
0.28
Segregated solver iteration 103.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.19   0.5000000        0.19 2503 1246 1246 15483  0.00067  2.2e-05
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.051     4.5e+04   0.3500000       0.051 6120 3617 3617 19450  0.00093
     -
   2       0.042     3.6e+04   0.3500000       0.042 6121 3618 3618 19455  0.00077
     -
   3       0.036     2.9e+04   0.3500000       0.036 6122 3619 3619 19460  0.00066
     -
Solution error estimates for segregated groups
```

```
0.096, 0.045
Residual error estimates for segregated groups
97, 2.9e+04
Pseudo time-stepping CFL-ratio:
0.28
Segregated solver iteration 104.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1         0.2   0.5000000         0.2 2505 1247 1247 15495  0.00099        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.053     4.4e+04   0.3500000       0.053 6125 3620 3620 19467  0.00099
     -
   2       0.043     3.5e+04   0.3500000       0.043 6126 3621 3621 19472  0.00081
     -
   3       0.036     2.9e+04   0.3500000       0.036 6127 3622 3622 19477  0.00072
     -
Solution error estimates for segregated groups
0.1, 0.047
Residual error estimates for segregated groups
77, 2.9e+04
Pseudo time-stepping CFL-ratio:
0.3
Segregated solver iteration 105.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.17   0.5000000        0.17 2507 1248 1248 15512   0.0008  4.4e-05
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.045       4e+04   0.3500000       0.045 6130 3623 3623 19484  0.00085
     -
   2       0.037     3.2e+04   0.3500000       0.037 6131 3624 3624 19489   0.0007
     -
   3        0.03     2.7e+04   0.3500000        0.03 6132 3625 3625 19494  0.00062
     -
Solution error estimates for segregated groups
0.085, 0.04
Residual error estimates for segregated groups
67, 2.7e+04
Pseudo time-stepping CFL-ratio:
0.3
Segregated solver iteration 106.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.16   0.5000000        0.16 2509 1249 1249 15525  0.00092        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.042     3.9e+04   0.3500000       0.042 6135 3626 3626 19501  0.00093
     -
   2       0.032     3.1e+04   0.3500000       0.032 6136 3627 3627 19506  0.00073
     -
   3       0.026     2.5e+04   0.3500000       0.026 6137 3628 3628 19511  0.00063
     -
```

```
Solution error estimates for segregated groups
0.081, 0.035
Residual error estimates for segregated groups
63, 2.5e+04
Pseudo time-stepping CFL-ratio:
0.31
Segregated solver iteration 107.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.15   0.5000000        0.15 2511 1250 1250 15539  0.00058        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.038     3.7e+04   0.3500000       0.038 6140 3629 3629 19518  0.00091
     -
   2       0.029     2.9e+04   0.3500000       0.029 6141 3630 3630 19523  0.00079
     -
   3       0.023     2.4e+04   0.3500000       0.023 6142 3631 3631 19528  0.00065
     -
Solution error estimates for segregated groups
0.074, 0.031
Residual error estimates for segregated groups
60, 2.4e+04
Pseudo time-stepping CFL-ratio:
0.32
Segregated solver iteration 108.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.16   0.5000000        0.16 2513 1251 1251 15553  0.00064        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.044     3.5e+04   0.3500000       0.044 6145 3632 3632 19535    0.001
     -
   2       0.034     2.8e+04   0.3500000       0.034 6146 3633 3633 19540  0.00093
     -
   3       0.026     2.2e+04   0.3500000       0.026 6147 3634 3634 19545  0.00077
     -
Solution error estimates for segregated groups
0.079, 0.036
Residual error estimates for segregated groups
57, 2.2e+04
Pseudo time-stepping CFL-ratio:
0.33
Segregated solver iteration 109.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.16   0.5000000        0.16 2515 1252 1252 15566  0.00065        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.049     3.2e+04   0.3500000       0.049 6150 3635 3635 19552  0.00091
     -
   2       0.037     2.5e+04   0.3500000       0.037 6151 3636 3636 19557  0.00092
     -
```

```
   3       0.029       2e+04   0.3500000       0.029 6152 3637 3637 19562  0.00077
     -
Solution error estimates for segregated groups
0.079, 0.04
Residual error estimates for segregated groups
53, 2e+04
Pseudo time-stepping CFL-ratio:
0.32
Segregated solver iteration 110.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.16   0.5000000        0.16 2517 1253 1253 15578  0.00087        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1        0.05     2.9e+04   0.3500000        0.05 6155 3638 3638 19569  0.00086
     -
   2       0.037     2.3e+04   0.3500000       0.037 6156 3639 3639 19574   0.0009
     -
   3       0.029     1.9e+04   0.3500000       0.029 6157 3640 3640 19579  0.00077
     -
Solution error estimates for segregated groups
0.079, 0.04
Residual error estimates for segregated groups
49, 1.9e+04
Pseudo time-stepping CFL-ratio:
0.33
Segregated solver iteration 111.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.15   0.5000000        0.15 2519 1254 1254 15590  0.00091        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.045     2.6e+04   0.3500000       0.045 6160 3641 3641 19586  0.00085
     -
   2       0.034     2.2e+04   0.3500000       0.034 6161 3642 3642 19591  0.00088
     -
   3       0.026     1.9e+04   0.3500000       0.026 6162 3643 3643 19596  0.00077
     -
Solution error estimates for segregated groups
0.073, 0.037
Residual error estimates for segregated groups
44, 1.9e+04
Pseudo time-stepping CFL-ratio:
0.33
Segregated solver iteration 112.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.14   0.5000000        0.14 2521 1255 1255 15603  0.00067        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1        0.04     2.4e+04   0.3500000        0.04 6165 3644 3644 19603  0.00092
     -
```

```
   2        0.03     2.1e+04   0.3500000        0.03 6166 3645 3645 19608  0.00086
     -
   3       0.024     1.9e+04   0.3500000       0.024 6167 3646 3646 19613  0.00077
     -
Solution error estimates for segregated groups
0.068, 0.033
Residual error estimates for segregated groups
41, 1.9e+04
Pseudo time-stepping CFL-ratio:
0.34
Segregated solver iteration 113.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.13   0.5000000        0.13 2523 1256 1256 15616  0.00089        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.036     2.3e+04   0.3500000       0.036 6170 3647 3647 19620  0.00096
     -
   2       0.027     2.1e+04   0.3500000       0.027 6171 3648 3648 19625  0.00082
     -
   3       0.022     1.9e+04   0.3500000       0.022 6172 3649 3649 19630  0.00075
     -
Solution error estimates for segregated groups
0.064, 0.03
Residual error estimates for segregated groups
37, 1.9e+04
Pseudo time-stepping CFL-ratio:
0.35
Segregated solver iteration 114.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.12   0.5000000        0.12 2525 1257 1257 15630  0.00064        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.035     2.2e+04   0.3500000       0.035 6175 3650 3650 19637  0.00096
     -
   2       0.026       2e+04   0.3500000       0.026 6176 3651 3651 19642  0.00079
     -
   3       0.021     1.9e+04   0.3500000       0.021 6177 3652 3652 19647  0.00074
     -
Solution error estimates for segregated groups
0.061, 0.029
Residual error estimates for segregated groups
34, 1.9e+04
Pseudo time-stepping CFL-ratio:
0.36
Segregated solver iteration 115.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.11   0.5000000        0.11 2527 1258 1258 15644  0.00064        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
```

```
   1       0.034     2.1e+04   0.3500000       0.034 6180 3653 3653 19654  0.00091
     -
   2       0.025     1.9e+04   0.3500000       0.025 6181 3654 3654 19659  0.00076
     -
   3        0.02     1.8e+04   0.3500000        0.02 6182 3655 3655 19664  0.00071
     -
Solution error estimates for segregated groups
0.056, 0.028
Residual error estimates for segregated groups
30, 1.8e+04
Pseudo time-stepping CFL-ratio:
0.36
Segregated solver iteration 116.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.097   0.5000000       0.097 2529 1259 1259 15658  0.00075        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.032       2e+04   0.3500000       0.032 6185 3656 3656 19671  0.00087
     -
   2       0.023     1.8e+04   0.3500000       0.023 6186 3657 3657 19676  0.00073
     -
   3       0.018     1.7e+04   0.3500000       0.018 6187 3658 3658 19681  0.00067
     -
Solution error estimates for segregated groups
0.048, 0.026
Residual error estimates for segregated groups
26, 1.7e+04
Pseudo time-stepping CFL-ratio:
0.37
Segregated solver iteration 117.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.08   0.5000000        0.08 2531 1260 1260 15673  0.00099        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.028     1.8e+04   0.3500000       0.028 6190 3659 3659 19688  0.00085
     -
   2       0.021     1.6e+04   0.3500000       0.021 6191 3660 3660 19693  0.00069
     -
   3       0.016     1.5e+04   0.3500000       0.016 6192 3661 3661 19698  0.00063
     -
Solution error estimates for segregated groups
0.04, 0.023
Residual error estimates for segregated groups
23, 1.5e+04
Pseudo time-stepping CFL-ratio:
0.39
Segregated solver iteration 118.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.065   0.5000000       0.065 2533 1261 1261 15690  0.00083        -
Turbulence variables
```

```
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.025     1.6e+04   0.3500000       0.025 6195 3662 3662 19705  0.00088
     -
   2       0.018     1.4e+04   0.3500000       0.018 6196 3663 3663 19710  0.00065
     -
   3       0.014     1.3e+04   0.3500000       0.014 6197 3664 3664 19715  0.00058
     -
Solution error estimates for segregated groups
0.033, 0.02
Residual error estimates for segregated groups
22, 1.3e+04
Pseudo time-stepping CFL-ratio:
0.41
Segregated solver iteration 119.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.054   0.5000000       0.054 2535 1262 1262 15708  0.00094        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.022     1.4e+04   0.3500000       0.022 6200 3665 3665 19722  0.00093
     -
   2       0.016     1.2e+04   0.3500000       0.016 6201 3666 3666 19727  0.00062
     -
   3       0.013     1.1e+04   0.3500000       0.013 6202 3667 3667 19732  0.00052
     -
Solution error estimates for segregated groups
0.027, 0.018
Residual error estimates for segregated groups
21, 1.1e+04
Pseudo time-stepping CFL-ratio:
0.43
Segregated solver iteration 120.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.046   0.5000000       0.046 2537 1263 1263 15727  0.00096        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.019     1.3e+04   0.3500000       0.019 6205 3668 3668 19739  0.00089
     -
   2       0.014       1e+04   0.3500000       0.014 6206 3669 3669 19744  0.00053
     -
   3       0.011     9.1e+03   0.3500000       0.011 6207 3670 3670 19748  0.00088
     -
Solution error estimates for segregated groups
0.023, 0.015
Residual error estimates for segregated groups
20, 9.1e+03
Pseudo time-stepping CFL-ratio:
0.45
Segregated solver iteration 121.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.039   0.5000000       0.039 2539 1264 1264 15747  0.00089        -
```

```
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.016     1.1e+04   0.3500000       0.016 6210 3671 3671 19755  0.00075
     -
   2       0.012     8.7e+03   0.3500000       0.012 6211 3672 3672 19759  0.00081
     -
   3      0.0088     7.4e+03   0.3500000      0.0088 6212 3673 3673 19763  0.00071
     -
Solution error estimates for segregated groups
0.019, 0.013
Residual error estimates for segregated groups
20, 7.4e+03
Pseudo time-stepping CFL-ratio:
0.47
Segregated solver iteration 122.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.032   0.5000000       0.032 2541 1265 1265 15768  0.00073        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.012     9.3e+03   0.3500000       0.012 6215 3674 3674 19770  0.00055
     -
   2      0.0089     7.4e+03   0.3500000      0.0089 6216 3675 3675 19774  0.00063
     -
   3      0.0068     6.2e+03   0.3500000      0.0068 6217 3676 3676 19778  0.00058
     -
Solution error estimates for segregated groups
0.016, 0.0096
Residual error estimates for segregated groups
19, 6.2e+03
Pseudo time-stepping CFL-ratio:
0.49
Segregated solver iteration 123.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.026   0.5000000       0.026 2543 1266 1266 15789  0.00081        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0092     8.1e+03   0.3500000      0.0092 6220 3677 3677 19784  0.00081
     -
   2      0.0067     6.4e+03   0.3500000      0.0067 6221 3678 3678 19788  0.00053
     -
   3      0.0052     5.4e+03   0.3500000      0.0052 6222 3679 3679 19792   0.0005
     -
Solution error estimates for segregated groups
0.013, 0.0072
Residual error estimates for segregated groups
18, 5.4e+03
Pseudo time-stepping CFL-ratio:
0.52
Segregated solver iteration 124.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
```

```
   1        0.02   0.5000000        0.02 2545 1267 1267 15810  0.00087        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0068     6.9e+03   0.3500000      0.0068 6225 3680 3680 19798  0.00068
     -
   2       0.005     5.6e+03   0.3500000       0.005 6226 3681 3681 19802  0.00046
     -
   3       0.004     4.9e+03   0.3500000       0.004 6227 3682 3682 19806  0.00044
     -
Solution error estimates for segregated groups
0.0099, 0.0054
Residual error estimates for segregated groups
16, 4.9e+03
Pseudo time-stepping CFL-ratio:
0.55
Segregated solver iteration 125.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.014   0.5000000       0.014 2547 1268 1268 15830  0.00096        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1       0.005     5.7e+03   0.3500000       0.005 6230 3683 3683 19812  0.00056
     -
   2      0.0037     4.9e+03   0.3500000      0.0037 6231 3684 3684 19815  0.00098
     -
   3      0.0031     4.5e+03   0.3500000      0.0031 6232 3685 3685 19818    0.001
     -
Solution error estimates for segregated groups
0.0072, 0.004
Residual error estimates for segregated groups
14, 4.5e+03
Pseudo time-stepping CFL-ratio:
0.58
Segregated solver iteration 126.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1        0.01   0.5000000        0.01 2549 1269 1269 15848  0.00094        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0038     4.6e+03   0.3500000      0.0038 6235 3686 3686 19823  0.00085
     -
   2      0.0029     4.2e+03   0.3500000      0.0029 6236 3687 3687 19826  0.00086
     -
   3      0.0024       4e+03   0.3500000      0.0024 6237 3688 3688 19829  0.00088
     -
Solution error estimates for segregated groups
0.0051, 0.0031
Residual error estimates for segregated groups
11, 4e+03
Pseudo time-stepping CFL-ratio:
0.62
Segregated solver iteration 127.
Velocity u, Pressure p2
```

```
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0087   0.5000000      0.0087 2551 1270 1270 15869  0.00086        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0032     3.9e+03   0.3500000      0.0032 6240 3689 3689 19834  0.00077
     -
   2      0.0024     3.7e+03   0.3500000      0.0024 6241 3690 3690 19837  0.00076
     -
   3       0.002     3.6e+03   0.3500000       0.002 6242 3691 3691 19840  0.00079
     -
Solution error estimates for segregated groups
0.0044, 0.0026
Residual error estimates for segregated groups
8.9, 3.6e+03
Pseudo time-stepping CFL-ratio:
0.66
Segregated solver iteration 128.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0086   0.5000000      0.0086 2553 1271 1271 15890  0.00095        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0029     3.5e+03   0.3500000      0.0029 6245 3692 3692 19845  0.00075
     -
   2      0.0021     3.3e+03   0.3500000      0.0021 6246 3693 3693 19848  0.00067
     -
   3      0.0017     3.2e+03   0.3500000      0.0017 6247 3694 3694 19851  0.00071
     -
Solution error estimates for segregated groups
0.0043, 0.0023
Residual error estimates for segregated groups
7.1, 3.2e+03
Pseudo time-stepping CFL-ratio:
0.68
Segregated solver iteration 129.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.008   0.5000000       0.008 2555 1272 1272 15911  0.00079        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0026     3.1e+03   0.3500000      0.0026 6250 3695 3695 19856   0.0007
     -
   2      0.0018     2.9e+03   0.3500000      0.0018 6251 3696 3696 19859  0.00058
     -
   3      0.0015     2.7e+03   0.3500000      0.0015 6252 3697 3697 19862  0.00062
     -
Solution error estimates for segregated groups
0.004, 0.002
Residual error estimates for segregated groups
5.8, 2.7e+03
Pseudo time-stepping CFL-ratio:
0.71
Segregated solver iteration 130.
```

```
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0068   0.5000000      0.0068 2557 1273 1273 15931  0.00086        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0022     2.7e+03   0.3500000      0.0022 6255 3698 3698 19867  0.00062
     -
   2      0.0015     2.5e+03   0.3500000      0.0015 6256 3699 3699 19870   0.0005
     -
   3      0.0012     2.3e+03   0.3500000      0.0012 6257 3700 3700 19873  0.00054
     -
Solution error estimates for segregated groups
0.0034, 0.0016
Residual error estimates for segregated groups
4.9, 2.3e+03
Pseudo time-stepping CFL-ratio:
0.73
Segregated solver iteration 131.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0053   0.5000000      0.0053 2559 1274 1274 15950  0.00084        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0017     2.3e+03   0.3500000      0.0017 6260 3701 3701 19878  0.00051
     -
   2      0.0012       2e+03   0.3500000      0.0012 6261 3702 3702 19880  0.00095
     -
   3     0.00095     1.9e+03   0.3500000     0.00095 6262 3703 3703 19883   0.0005
     -
Solution error estimates for segregated groups
0.0027, 0.0013
Residual error estimates for segregated groups
4.1, 1.9e+03
Pseudo time-stepping CFL-ratio:
0.77
Segregated solver iteration 132.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1       0.004   0.5000000       0.004 2561 1275 1275 15968  0.00084        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0013     1.8e+03   0.3500000      0.0013 6265 3704 3704 19887  0.00078
     -
   2     0.00089     1.6e+03   0.3500000     0.00089 6266 3705 3705 19889  0.00076
     -
Solution error estimates for segregated groups
0.002, 0.00084
Residual error estimates for segregated groups
3.1, 1.6e+03
Pseudo time-stepping CFL-ratio:
0.8
Segregated solver iteration 133.
Velocity u, Pressure p2
```

```
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0026   0.5000000      0.0026 2563 1276 1276 15983  0.00095        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1      0.0011     1.6e+03   0.3500000      0.0011 6269 3706 3706 19893  0.00068
     -
   2     0.00076     1.4e+03   0.3500000     0.00076 6270 3707 3707 19895  0.00066
     -
Solution error estimates for segregated groups
0.0013, 0.00071
Residual error estimates for segregated groups
2.3, 1.4e+03
Pseudo time-stepping CFL-ratio:
0.85
Segregated solver iteration 134.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0018   0.5000000      0.0018 2565 1277 1277 15996  0.00088        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1     0.00085     1.3e+03   0.3500000     0.00085 6273 3708 3708 19899  0.00054
     -
Solution error estimates for segregated groups
0.00092, 0.00055
Residual error estimates for segregated groups
1.6, 1.3e+03
Pseudo time-stepping CFL-ratio:
0.9
Segregated solver iteration 135.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1      0.0012   0.5000000      0.0012 2567 1278 1278 16006  0.00098        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1     0.00077     1.2e+03   0.3500000     0.00077 6276 3709 3709 19902  0.00096
     -
Solution error estimates for segregated groups
0.00062, 0.0005
Residual error estimates for segregated groups
1.2, 1.2e+03
Pseudo time-stepping CFL-ratio:
0.95
Segregated solver iteration 136.
Velocity u, Pressure p2
Iter      SolEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1     0.00087   0.5000000     0.00087 2569 1279 1279 16015  0.00083        -
Turbulence variables
Iter      SolEst      ResEst     Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1     0.00067     1.1e+03   0.3500000     0.00067 6279 3710 3710 19905  0.00088
     -
Solution error estimates for segregated groups
0.00044, 0.00044
```

```
Residual error estimates for segregated groups
0.87, 1.1e+03
Pseudo time-stepping CFL-ratio:
1
Segregated solver iteration 137.
Velocity u, Pressure p2
Iter      SolEst      Damping     Stepsize #Res #Jac #Sol LinIt   LinErr   LinRes
   1     0.00059   0.5000000     0.00059 2571 1280 1280 16022  0.00091        -
Turbulence variables
Iter      SolEst       ResEst      Damping    Stepsize #Res #Jac #Sol LinIt   LinErr
LinRes
   1     0.00057     9.4e+02   0.3500000     0.00057 6282 3711 3711 19908  0.00077
     -
Solution error estimates for segregated groups
0.0003, 0.00037
Residual error estimates for segregated groups
0.69, 9.4e+02
Pseudo time-stepping CFL-ratio:
1
Solution time: 118534 s. (1 day, 8 hours, 55 minutes, 34 seconds)
Physical memory: 13.52 GB
Virtual memory: 21.52 GB
Ended at Feb 24, 2021 8:37:38 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	Sweep Geschwindigkeit
Sweep type	All combinations
Run continuation for	No parameter

PARAMETERS

Parameter name	Parameter value list	Parameter unit
f	range(50,50,600)	rpm

Segregated 1 (se1)

GENERAL

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

Description	Value
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
Pivoting perturbation	1.0E-13

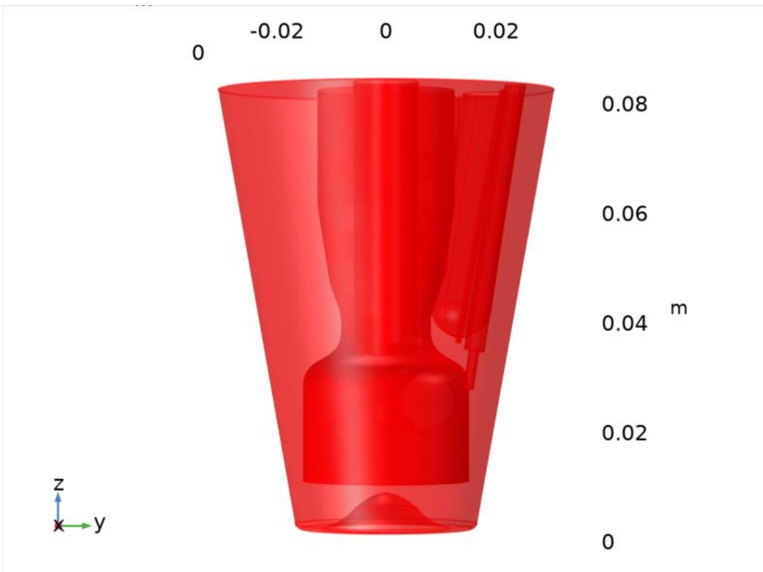
4 Results

4.1 DATASETS

4.1.1 Study 1/Solution 1

SOLUTION

Description	Value
Solution	Solution 1
Component	Save Point Geometry 1



Dataset: Study 1/Solution 1

4.1.2 Exterior Walls

DATA

Description	Value
Dataset	Study 1/Solution 1

PARAMETERIZATION

Description	Value
x- and y-axes	Surface parameters

4.1.3 Cut Plane 1

DATA

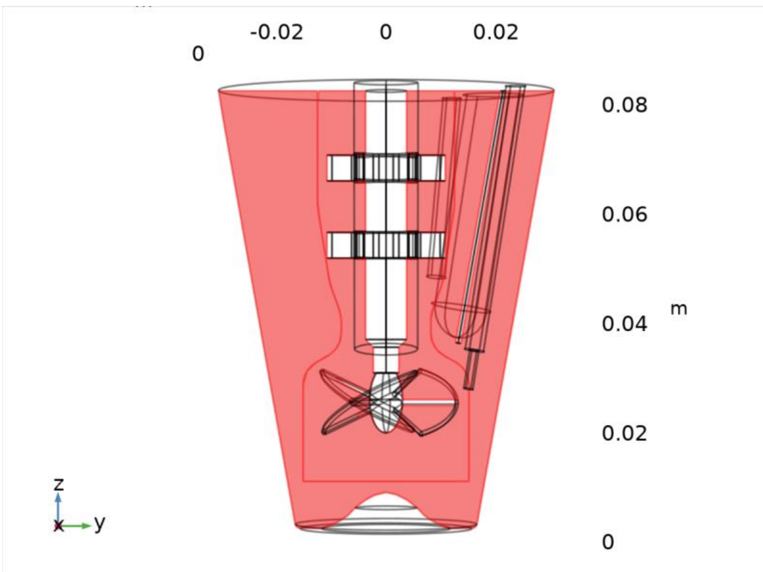
Description	Value
Dataset	Study 1/Solution 1

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

4.2 DERIVED VALUES

4.2.1 Volume Average 1

OUTPUT

Evaluated in	Table 1

DATA

Description	Value
Dataset	Study 1/Solution 1

EXPRESSIONS

Expression	Unit	Description
spf.U	m/s	Velocity magnitude
spf.sr	1/s	Shear rate

Expression	Unit	Description
spf.Qvd	W/m^3	Viscous dissipation

INTEGRATION SETTINGS

Description	Value
Integration order	4

4.2.2 Volume Maximum 1

OUTPUT

Evaluated in	Table 2

DATA

Description	Value
Dataset	Study 1/Solution 1

EXPRESSIONS

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

4.3 TABLES

4.3.1 Table 1

Volume Average 1

f (rpm)	Velocity magnitude (m/s)	Shear rate (1/s)	Viscous dissipation (W/m^3)
50.000	0.011904	3.8207	0.24250
100.00	0.024732	8.3109	1.2524
150.00	0.038566	13.235	3.6306
200.00	0.052802	18.364	7.8820
250.00	0.067124	23.503	14.465
300.00	0.081469	28.615	23.856
350.00	0.095826	33.719	36.466
400.00	0.11024	38.822	52.675
450.00	0.12468	43.929	72.896
500.00	0.13911	49.054	97.576
550.00	0.14590	50.800	137.94
600.00	0.15928	55.525	176.93

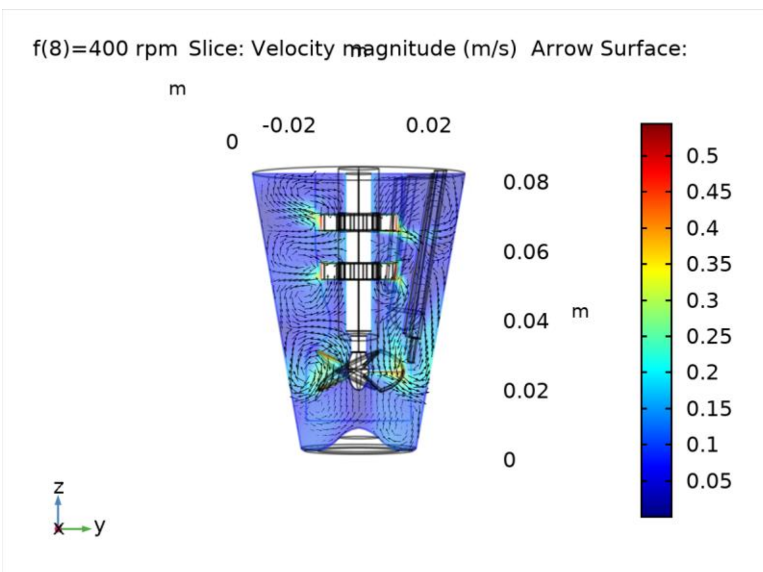
4.3.2 Table 2

Volume Maximum 1

f (rpm)	Velocity magnitude (m/s)	Shear rate (1/s)	Viscous dissipation (W/m^3)
50.000	0.58831	3466.2	36894
100.00	0.52373	3756.1	38875
150.00	0.49238	3974.3	45738
200.00	0.49172	5053.2	71293
250.00	0.52419	6245.8	1.2510E5
300.00	0.56941	7306.2	1.9374E5
350.00	0.61504	8221.5	2.6657E5
400.00	0.66203	9383.2	3.5995E5
450.00	0.71690	10536	4.7886E5
500.00	0.79614	11747	6.2198E5
550.00	0.87201	13024	7.9865E5
600.00	0.95249	14363	1.0147E6

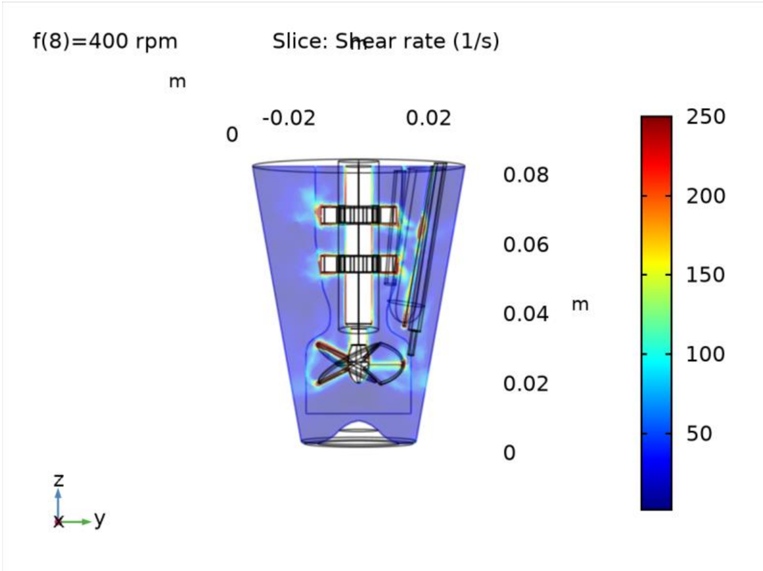
4.4 PLOT GROUPS

4.4.1 3D Plot Group 1



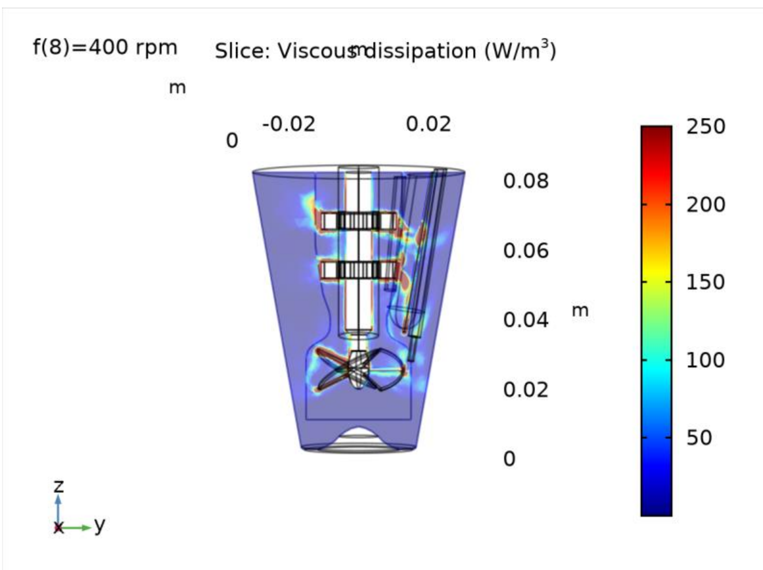
Slice: Velocity magnitude (m/s) Arrow Surface:

4.4.2 3D Plot Group 2



Slice: Shear rate (1/s)

4.4.3 3D Plot Group 3



Slice: Viscous dissipation (W/m^3)