[](http://www.comsol.com/)

Untitled

|  |  |
| --- | --- |
| Report date | Jul 31, 2020 12:52:28 PM |

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1. Global Definitions

|  |  |
| --- | --- |
| Date | Jul 31, 2020 12:50:05 PM |

Global settings

|  |  |
| --- | --- |
| Name | Untitled.mph |
| Version | COMSOL Multiphysics 5.5 (Build: 359) |
| Unit system | SI |

Used products

|  |
| --- |
| COMSOL Multiphysics |
| Design Module |

* 1. Parameters

Parameters 1

| **Name** | **Expression** | **Value** | **Description** |
| --- | --- | --- | --- |
| c0 | 1000[mol/m^3] | 1000 mol/m³ |  |
| k\_ads | 1e-6[m^3/(mol\*s)] | 1E−6 m³/(s·mol) |  |
| k\_des | 1e-9[1/s] | 1E−9 1/s |  |
| Gamma\_s | 1000[mol/m^2] | 1000 mol/m² |  |
| Ds | 1e-11[m^2/s] | 1E−11 m²/s |  |
| D | 1e-9[m^2/s] | 1E−9 m²/s |  |
| v\_max | 1[mm/s] | 0.001 m/s |  |
| delta | 0.1[mm] | 1E−4 m |  |

1. Component 1

|  |  |
| --- | --- |
| Date | Jul 31, 2020 12:50:08 PM |

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 |

* 1. Definitions
     1. Variables

#### Variables 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundary 5 |

| **Name** | **Expression** | **Unit** | **Description** |
| --- | --- | --- | --- |
| R | k\_ads\*c\*(Gamma\_s - cs) - k\_des\*cs | mol/(m²·s) | Surface reaction rate |

#### Variables 2

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: Domain 1 |

| **Name** | **Expression** | **Unit** | **Description** |
| --- | --- | --- | --- |
| v\_lam | v\_max\*(1 - ((x - 0.5\*delta)/(0.5\*delta))^2) | m/s | Inlet velocity profile |

* + 1. Coordinate Systems

#### Boundary System 1

|  |  |
| --- | --- |
| Coordinate system type | Boundary system |
| Tag | sys1 |

Coordinate names

| **First** | **Second** | **Third** |
| --- | --- | --- |
| t1 | n | to |

* 1. Geometry 1

Units

|  |  |
| --- | --- |
| Length unit | m |
| Angular unit | deg |

Geometry statistics

| **Description** | **Value** |
| --- | --- |
| Space dimension | 2 |
| Number of domains | 1 |
| Number of boundaries | 6 |
| Number of vertices | 6 |

* + 1. Rectangle 1 (r1)

Position

| **Description** | **Value** |
| --- | --- |
| Position | {0, -0.1} |

Size

| **Description** | **Value** |
| --- | --- |
| Width | 30 |
| Height | 90 |

* + 1. Point 1 (pt1)

Point

| **Description** | **Value** |
| --- | --- |
| Point coordinate | {30, 10} |

* + 1. Point 2 (pt2)

Point

| **Description** | **Value** |
| --- | --- |
| Point coordinate | {30, 15} |

* 1. Transport of Diluted Species

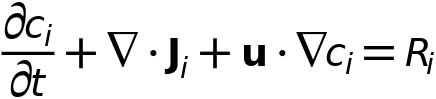
Used products

|  |
| --- |
| COMSOL Multiphysics |

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: All domains |

Equations





* + 1. Interface settings

#### Discretization

Settings

| **Description** | **Value** |
| --- | --- |
| Concentration | Linear |

#### Transport mechanisms

Settings

| **Description** | **Value** |
| --- | --- |
| Convection | On |
| Migration in electric field | Off |
| Mass transfer in porous media | Off |

#### Consistent stabilization

Settings

| **Description** | **Value** |
| --- | --- |
| Streamline diffusion | On |
| Crosswind diffusion | On |
| Equation residual | Approximate residual |
| Crosswind diffusion type | Do Carmo and Galeão |

#### Inconsistent stabilization

Settings

| **Description** | **Value** |
| --- | --- |
| Isotropic diffusion | Off |

#### Advanced settings

Settings

| **Description** | **Value** |
| --- | --- |
| Convective term | Nonconservative form |

* + 1. Variables

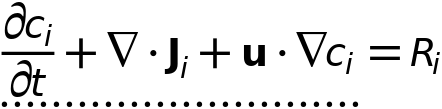
| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| tds.R\_c | 0 | mol/(m³·s) | Total rate expression | Domain 1 | + operation |
| tds.cP\_c | 0 | mol/kg | Concentration species absorbed to the solid | Domain 1 | + operation |
| tds.cP\_c | 0 | mol/kg | Concentration species absorbed to the solid | Boundaries 1–6 | + operation |
| tds.KP\_c | 0 | m³/kg | Adsorption isotherm, first concentration derivative | Domain 1 | + operation |
| tds.KP\_c | 0 | m³/kg | Adsorption isotherm, first concentration derivative | Boundaries 1–6 | + operation |
| tds.epsilon\_p | 1 | 1 | Porosity | Domain 1 |  |
| tds.theta | tds.epsilon\_p | 1 | Liquid volume fraction | Domain 1 |  |
| tds.av | 0 | 1 | Gas volume fraction | Domain 1 |  |
| tds.nx | dnx | 1 | Normal vector, x component | Boundaries 1–6 |  |
| tds.ny | dny | 1 | Normal vector, y component | Boundaries 1–6 |  |
| tds.nz | 0 | 1 | Normal vector, z component | Boundaries 1–6 |  |
| tds.nxmesh | dnxmesh | 1 | Normal vector (mesh), x component | Boundaries 1–6 |  |
| tds.nymesh | dnymesh | 1 | Normal vector (mesh), y component | Boundaries 1–6 |  |
| tds.nzmesh | 0 | 1 | Normal vector (mesh), z component | Boundaries 1–6 |  |
| tds.nxc | root.nxc/tds.ncLen | 1 | Normal vector, x component | Boundaries 1–6 |  |
| tds.nyc | root.nyc/tds.ncLen | 1 | Normal vector, y component | Boundaries 1–6 |  |
| tds.nzc | 0 | 1 | Normal vector, z component | Boundaries 1–6 |  |
| tds.ncLen | sqrt(root.nxc^2+root.nyc^2+eps) | 1 | Help variable | Boundaries 1–6 |  |
| tds.cbf\_c | 0 | mol/(m²·s) | Convective boundary flux | Boundaries 1–6 |  |
| tds.u | 0 | m/s | Velocity field, x component | Domain 1 |  |
| tds.v | 0 | m/s | Velocity field, y component | Domain 1 |  |
| tds.w | 0 | m/s | Velocity field, z component | Domain 1 |  |

* + 1. Transport Properties 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: All domains |

Equations





#### Convection

Settings

| **Description** | **Value** |
| --- | --- |
| Velocity field | User defined |
| Velocity field | {0, v\_lam, 0} |

#### Diffusion

Settings

| **Description** | **Value** |
| --- | --- |
| Material | None |
| Diffusion coefficient | User defined |
| Diffusion coefficient | {{D, 0, 0}, {0, D, 0}, {0, 0, D}} |

#### Coordinate system selection

Settings

| **Description** | **Value** |
| --- | --- |
| Coordinate system | Global coordinate system |

#### Model input

Settings

| **Description** | **Value** |
| --- | --- |
| Temperature | Common model input |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** | **Details** |
| --- | --- | --- | --- | --- | --- |
| domflux.cx | tds.dflux\_cx | mol/(m²·s) | Domain flux, x component | Domain 1 |  |
| domflux.cy | tds.dflux\_cy | mol/(m²·s) | Domain flux, y component | Domain 1 |  |
| tds.ndflux\_c | tds.bndFlux\_c | mol/(m²·s) | Normal diffusive flux | Boundaries 1–6 |  |
| tds.ncflux\_c | tds.cflux\_cx\*tds.nxc+tds.cflux\_cy\*tds.nyc+tds.cflux\_cz\*tds.nzc | mol/(m²·s) | Normal convective flux | Boundaries 1–6 |  |
| tds.ntflux\_c | tds.bndFlux\_c+tds.cflux\_cx\*tds.nxc+tds.cflux\_cy\*tds.nyc+tds.cflux\_cz\*tds.nzc | mol/(m²·s) | Normal total flux | Boundaries 1–6 |  |
| tds.u | model.input.u1 | m/s | Velocity field, x component | Domain 1 | Meta |
| tds.v | model.input.u2 | m/s | Velocity field, y component | Domain 1 | Meta |
| tds.w | model.input.u3 | m/s | Velocity field, z component | Domain 1 | Meta |
| tds.bndFlux\_c | -dflux\_spatial(c) | mol/(m²·s) | Boundary flux | Boundaries 1–6 |  |
| tds.D\_cxx | D | m²/s | Diffusion coefficient, xx component | Domain 1 | + operation |
| tds.D\_cyx | 0 | m²/s | Diffusion coefficient, yx component | Domain 1 | + operation |
| tds.D\_czx | 0 | m²/s | Diffusion coefficient, zx component | Domain 1 | + operation |
| tds.D\_cxy | 0 | m²/s | Diffusion coefficient, xy component | Domain 1 | + operation |
| tds.D\_cyy | D | m²/s | Diffusion coefficient, yy component | Domain 1 | + operation |
| tds.D\_czy | 0 | m²/s | Diffusion coefficient, zy component | Domain 1 | + operation |
| tds.D\_cxz | 0 | m²/s | Diffusion coefficient, xz component | Domain 1 | + operation |
| tds.D\_cyz | 0 | m²/s | Diffusion coefficient, yz component | Domain 1 | + operation |
| tds.D\_czz | D | m²/s | Diffusion coefficient, zz component | Domain 1 | + operation |
| tds.Dav\_c | 0.5\*(tds.D\_cxx+tds.D\_cyy) | m²/s | Average diffusion coefficient | Domain 1 |  |
| tds.tflux\_cx | tds.dflux\_cx+tds.cflux\_cx | mol/(m²·s) | Total flux, x component | Domain 1 | + operation |
| tds.tflux\_cy | tds.dflux\_cy+tds.cflux\_cy | mol/(m²·s) | Total flux, y component | Domain 1 | + operation |
| tds.tflux\_cz | tds.dflux\_cz+tds.cflux\_cz | mol/(m²·s) | Total flux, z component | Domain 1 | + operation |
| tds.dfluxMag\_c | sqrt(tds.dflux\_cx^2+tds.dflux\_cy^2+tds.dflux\_cz^2) | mol/(m²·s) | Diffusive flux magnitude | Domain 1 |  |
| tds.tfluxMag\_c | sqrt(tds.tflux\_cx^2+tds.tflux\_cy^2+tds.tflux\_cz^2) | mol/(m²·s) | Total flux magnitude | Domain 1 |  |
| tds.dflux\_cx | -tds.D\_cxx\*cx-tds.D\_cxy\*cy | mol/(m²·s) | Diffusive flux, x component | Domain 1 |  |
| tds.dflux\_cy | -tds.D\_cyx\*cx-tds.D\_cyy\*cy | mol/(m²·s) | Diffusive flux, y component | Domain 1 |  |
| tds.dflux\_cz | -tds.D\_czx\*cx-tds.D\_czy\*cy | mol/(m²·s) | Diffusive flux, z component | Domain 1 |  |
| tds.grad\_cx | cx | mol/m⁴ | Concentration gradient, x component | Domain 1 |  |
| tds.grad\_cy | cy | mol/m⁴ | Concentration gradient, y component | Domain 1 |  |
| tds.grad\_cz | 0 | mol/m⁴ | Concentration gradient, z component | Domain 1 |  |
| tds.cflux\_cx | c\*tds.u | mol/(m²·s) | Convective flux, x component | Domain 1 |  |
| tds.cflux\_cy | c\*tds.v | mol/(m²·s) | Convective flux, y component | Domain 1 |  |
| tds.cflux\_cz | c\*tds.w | mol/(m²·s) | Convective flux, z component | Domain 1 |  |
| tds.cfluxMag\_c | sqrt(tds.cflux\_cx^2+tds.cflux\_cy^2+tds.cflux\_cz^2) | mol/(m²·s) | Convective flux magnitude | Domain 1 |  |
| tds.Res\_c | d(c,t)+tds.u\*cx+tds.v\*cy-tds.R\_c | mol/(m³·s) | Equation residual | Domain 1 |  |

#### Shape functions

| **Name** | **Shape function** | **Unit** | **Description** | **Shape frame** | **Selection** |
| --- | --- | --- | --- | --- | --- |
| c | Lagrange (Linear) | mol/m³ | Concentration | Spatial | Domain 1 |

#### Weak expressions

| **Weak expression** | **Integration order** | **Integration frame** | **Selection** |
| --- | --- | --- | --- |
| -ct\*test(c)+tds.dflux\_cx\*test(cx)+tds.dflux\_cy\*test(cy) | 2 | Spatial | Domain 1 |
| -(tds.u\*cx+tds.v\*cy)\*test(c)\*(isScalingSystemDomain==0) | 2 | Spatial | Domain 1 |
| tds.cbf\_c\*test(c) | 2 | Spatial | Boundaries 1–6 |
| tds.streamline\*(isScalingSystemDomain==0) | 2 | Spatial | Domain 1 |
| tds.crosswind\*(isScalingSystemDomain==0) | 4 | Spatial | Domain 1 |

* + 1. No Flux 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: All boundaries |

Equations



#### Convection

Settings

| **Description** | **Value** |
| --- | --- |
| Include | Off |

* + 1. Initial Values 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Geometry geom1: Dimension 2: All domains |

#### Initial values

Settings

| **Description** | **Value** |
| --- | --- |
| Concentration | c0 |

* + 1. Concentration 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundary 2 |

Equations



#### Concentration

Settings

| **Description** | **Value** |
| --- | --- |
| Species c | On |
| Concentration | c0 |

#### Constraint settings

Settings

| **Description** | **Value** |
| --- | --- |
| Apply reaction terms on | All physics (symmetric) |
| Use weak constraints | Off |
| Constraint method | Elemental |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| tds.c0\_c | c0 | mol/m³ | Concentration | Boundary 2 |

#### Constraints

| **Constraint** | **Constraint force** | **Shape function** | **Selection** | **Details** |
| --- | --- | --- | --- | --- |
| -c+tds.c0\_c | test(-c+tds.c0\_c) | Lagrange (Linear) | Boundary 2 | Elemental |

* + 1. Flux 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundary 5 |

Equations



#### Convection

Settings

| **Description** | **Value** |
| --- | --- |
| Include | Off |

#### Inward flux

Settings

| **Description** | **Value** |
| --- | --- |
| Flux type | General inward flux |
| Species c | On |
|  | -R |

#### Weak expressions

| **Weak expression** | **Integration order** | **Integration frame** | **Selection** |
| --- | --- | --- | --- |
| -R\*test(c) | 2 | Spatial | Boundary 5 |

* + 1. Outflow 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundary 3 |

Equations



#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| tds.out1.c0\_avg\_c | tds.out1.int(c\*(tds.u\*tds.nx+tds.v\*tds.ny+tds.w\*tds.nz))/tds.out1.int(tds.u\*tds.nx+tds.v\*tds.ny+tds.w\*tds.nz) | mol/m³ | Concentration | Global |

#### Weak expressions

| **Weak expression** | **Integration order** | **Integration frame** | **Selection** |
| --- | --- | --- | --- |
| 0 | 2 | Spatial | Boundary 3 |

* + 1. Symmetry 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundaries 1, 4, 6 |

Equations



#### Convection

Settings

| **Description** | **Value** |
| --- | --- |
| Include | Off |

* 1. General Form Boundary PDE

Used products

|  |
| --- |
| COMSOL Multiphysics |

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundary 5 |

* + 1. Interface settings

#### Discretization

Settings

| **Description** | **Value** |
| --- | --- |
| Shape function type | Lagrange |
| Element order | Quadratic |
| Frame | Spatial |

#### Units

| **Dependent variable quantity** | **Unit** |
| --- | --- |
| Custom unit | mol/m^2 |

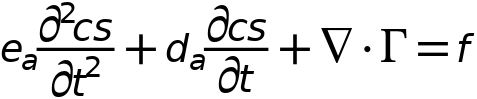
| **Source term quantity** | **Unit** |
| --- | --- |
| Custom unit | mol/(m^2\*s) |

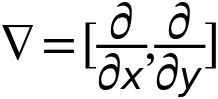
* + 1. General Form PDE 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: All boundaries |

Equations





Settings

| **Description** | **Value** |
| --- | --- |
| Source term | R |
| Conservative flux | {-csTx\*Ds, -csTy\*Ds} |
| Mass coefficient | 0 |
| Damping or mass coefficient | 1 |

#### Variables

| **Name** | **Expression** | **Unit** | **Description** | **Selection** |
| --- | --- | --- | --- | --- |
| domflux.csx | -csTx\*Ds | mol/(m·s) | Domain flux, x component | Boundary 5 |
| domflux.csy | -csTy\*Ds | mol/(m·s) | Domain flux, y component | Boundary 5 |

#### Shape functions

| **Name** | **Shape function** | **Unit** | **Description** | **Shape frame** | **Selection** |
| --- | --- | --- | --- | --- | --- |
| cs | Lagrange (Quadratic) | mol/m² | Dependent variable cs | Spatial | Boundary 5 |

* + 1. Initial Values 1

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: All boundaries |

Settings

| **Description** | **Value** |
| --- | --- |
| Initial value for cs | 0 |
| Initial time derivative of cs | 0 |

* 1. Mesh 1

Mesh statistics

| **Description** | **Value** |
| --- | --- |
| Minimum element quality | 0.6072 |
| Average element quality | 0.9516 |
| Triangle | 51686 |
| Edge element | 3424 |
| Vertex element | 6 |

* + 1. Size (size)

Settings

| **Description** | **Value** |
| --- | --- |
| Maximum element size | 6.03 |
| Minimum element size | 0.027 |
| Curvature factor | 0.3 |
| Maximum element growth rate | 1.3 |

* + 1. Free Triangular 1 (ftri1)

Selection

|  |  |
| --- | --- |
| Geometric entity level | Domain |
| Selection | Remaining |

#### Size 1 (size1)

Selection

|  |  |
| --- | --- |
| Geometric entity level | Boundary |
| Selection | Geometry geom1: Dimension 1: Boundary 5 |

Settings

| **Description** | **Value** |
| --- | --- |
| Maximum element size | 1.5[mm] |
| Minimum element size | 0.027 |
| Minimum element size | Off |
| Curvature factor | 0.3 |
| Curvature factor | Off |
| Resolution of narrow regions | Off |
| Maximum element growth rate | 1.3 |
| Maximum element growth rate | Off |
| Custom element size | Custom |

1. Study 1

Computation information

|  |  |
| --- | --- |
| Computation time |  |
| CPU | Intel(R) Xeon(R) CPU E5-2603 v4 @ 1.70GHz, 12 cores |
| Operating system | Linux |

* 1. Time Dependent

| **Times** | **Unit** |
| --- | --- |
| range(0,0.05,2) | s |

Study settings

| **Description** | **Value** |
| --- | --- |
| Include geometric nonlinearity | Off |

Study settings

| **Description** | **Value** |
| --- | --- |
| Times | {0, 0.05, 0.1, 0.15000000000000002, 0.2, 0.25, 0.30000000000000004, 0.35000000000000003, 0.4, 0.45, 0.5, 0.55, 0.6000000000000001, 0.65, 0.7000000000000001, 0.75, 0.8, 0.8500000000000001, 0.9, 0.9500000000000001, 1, 1.05, 1.1, 1.1500000000000001, 1.2000000000000002, 1.25, 1.3, 1.35, 1.4000000000000001, 1.4500000000000002, 1.5, 1.55, 1.6, 1.6500000000000001, 1.7000000000000002, 1.75, 1.8, 1.85, 1.9000000000000001, 1.9500000000000002, 2} |

Physics and variables selection

| **Physics interface** | **Discretization** |
| --- | --- |
| Transport of Diluted Species (tds) | physics |
| General Form Boundary PDE (gb) | physics |

Mesh selection

| **Geometry** | **Mesh** |
| --- | --- |
| Geometry 1 (geom1) | mesh1 |

* 1. Solver Configurations
     1. Solution 1

#### Compile Equations: Time Dependent (st1)

Study and step

| **Description** | **Value** |
| --- | --- |
| Use study | [Study 1](#cs8339262) |
| Use study step | [Time Dependent](#cs1742990) |

Log

<---- Compile Equations: Time Dependent in Study 1/Solution 1 (sol1) -----------

Started at Jul 31, 2020 12:52:04 PM.

Geometry shape order: Linear

Running on 2 x Intel(R) Xeon(R) CPU E5-2603 v4 at 1.70 GHz.

Using 2 sockets with 12 cores in total on nanos.

Available memory: 15.73 GB.

Time: 1 s.

Physical memory: 1.02 GB

Virtual memory: 8.24 GB

Ended at Jul 31, 2020 12:52:05 PM.

----- Compile Equations: Time Dependent in Study 1/Solution 1 (sol1) ---------->

#### Dependent Variables 1 (v1)

General

| **Description** | **Value** |
| --- | --- |
| Defined by study step | [Time Dependent](#cs1742990) |

Residual scaling

| **Description** | **Value** |
| --- | --- |
| Method | Manual |

Initial value calculation constants

| **Constant name** | **Initial value source** |
| --- | --- |
| t | range(0,0.05,2) |
| timestep | 0.002[s] |

Log

<---- Dependent Variables 1 in Study 1/Solution 1 (sol1) -----------------------

Started at Jul 31, 2020 12:52:05 PM.

Solution time: 0 s.

Physical memory: 1.02 GB

Virtual memory: 8.24 GB

Ended at Jul 31, 2020 12:52:05 PM.

----- Dependent Variables 1 in Study 1/Solution 1 (sol1) ---------------------->

##### Concentration (comp1.c) (comp1\_c)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.c |
| Internal variables | {comp1.uflux.c, comp1.dflux.c, comp1.tds.dt2Inv\_c} |

##### Dependent variable cs (comp1.cs) (comp1\_cs)

General

| **Description** | **Value** |
| --- | --- |
| Field components | comp1.cs |

#### Time-Dependent Solver 1 (t1)

General

| **Description** | **Value** |
| --- | --- |
| Defined by study step | [Time Dependent](#cs1742990) |
| Times | {0, 0.05, 0.1, 0.15000000000000002, 0.2, 0.25, 0.30000000000000004, 0.35000000000000003, 0.4, 0.45, 0.5, 0.55, 0.6000000000000001, 0.65, 0.7000000000000001, 0.75, 0.8, 0.8500000000000001, 0.9, 0.9500000000000001, 1, 1.05, 1.1, 1.1500000000000001, 1.2000000000000002, 1.25, 1.3, 1.35, 1.4000000000000001, 1.4500000000000002, 1.5, 1.55, 1.6, 1.6500000000000001, 1.7000000000000002, 1.75, 1.8, 1.85, 1.9000000000000001, 1.9500000000000002, 2} |
| Relative tolerance | 0.005 |

Time stepping

| **Description** | **Value** |
| --- | --- |
| Maximum BDF order | 2 |

Log

<---- Time-Dependent Solver 1 in Study 1/Solution 1 (sol1) ---------------------

Started at Jul 31, 2020 12:52:05 PM.

Time-dependent solver (BDF)

Number of degrees of freedom solved for: 34225 (plus 55116 internal DOFs).

Nonsymmetric matrix found.

Scales for dependent variables:

Concentration (comp1.c): 1e+03

Dependent variable cs (comp1.cs): 5.2e+06

Step        Time    Stepsize      Res  Jac  Sol Order Tfail NLfail   LinErr   LinRes

   0           0           - out    2    3    2                  0    2e-15  1.8e-14

   1       0.002       0.002        3    4    3     1     0      0  1.4e-14  1.6e-14

   2       0.004       0.002        4    5    4     1     0      0  2.9e-15  1.6e-14

   3       0.008       0.004        5    6    5     2     0      0  3.1e-15  1.6e-14

   4       0.016       0.008        6    7    6     1     0      0    1e-13  1.7e-14

   5       0.032       0.016        7    8    7     1     0      0    1e-11  1.6e-14

   -        0.05           - out

   6       0.064       0.032        8    9    8     1     0      0  3.4e-12  1.6e-14

   -         0.1           - out

   7       0.128       0.064        9   10    9     1     0      0  2.9e-10  1.6e-14

   -        0.15           - out

   -         0.2           - out

   -        0.25           - out

   8       0.256       0.128       10   11   10     1     0      0  1.4e-10  1.7e-14

   -         0.3           - out

   -        0.35           - out

   -         0.4           - out

   -        0.45           - out

   9       0.456         0.2       11   12   11     1     0      0  1.9e-09  1.6e-14

   -         0.5           - out

   -        0.55           - out

   -         0.6           - out

   -        0.65           - out

  10       0.656         0.2       12   13   12     1     0      0  1.5e-08  4.1e-14

   -         0.7           - out

   -        0.75           - out

   -         0.8           - out

   -        0.85           - out

  11       0.856         0.2       13   14   13     1     0      0    4e-10  1.5e-14

   -         0.9           - out

   -        0.95           - out

   -           1           - out

   -        1.05           - out

  12       1.056         0.2       14   15   14     1     0      0  2.7e-08  1.7e-14

   -         1.1           - out

   -        1.15           - out

   -         1.2           - out

   -        1.25           - out

  13       1.256         0.2       15   16   15     1     0      0  1.6e-09  1.5e-14

   -         1.3           - out

   -        1.35           - out

   -         1.4           - out

   -        1.45           - out

  14       1.456         0.2       16   17   16     1     0      0  1.8e-08  9.7e-15

   -         1.5           - out

   -        1.55           - out

   -         1.6           - out

   -        1.65           - out

  15       1.656         0.2       17   18   17     1     0      0  5.5e-09  6.9e-15

   -         1.7           - out

   -        1.75           - out

   -         1.8           - out

   -        1.85           - out

  16       1.856         0.2       18   19   18     2     0      0  1.5e-09  1.1e-14

   -         1.9           - out

   -        1.95           - out

   -           2           - out

  17       2.056         0.2       19   20   19     2     0      0  5.1e-09  9.6e-15

Time-stepping completed.

Solution time: 20 s.

Physical memory: 1.05 GB

Virtual memory: 8.26 GB

Ended at Jul 31, 2020 12:52:26 PM.

----- Time-Dependent Solver 1 in Study 1/Solution 1 (sol1) -------------------->

##### Fully Coupled 1 (fc1)

General

| **Description** | **Value** |
| --- | --- |
| Linear solver | [Direct 1](#cs6737112) |

Method and termination

| **Description** | **Value** |
| --- | --- |
| Damping factor | 0.9 |
| Jacobian update | Once per time step |
| Maximum number of iterations | 8 |
| Stabilization and acceleration | Anderson acceleration |
| Dimension of iteration space | 5 |

1. Results
   1. Datasets
      1. Study 1/Solution 1

Solution

| **Description** | **Value** |
| --- | --- |
| Solution | [Solution 1](#cs4632160) |
| Component | Save Point Geometry 1 |

* 1. Plot Groups
     1. Concentration (tds)
     2. Concentration species in reactor
     3. Concentration reacting species along active surface