

Computation of effective thermal conductivity with Abaqus Swift Comp GUI

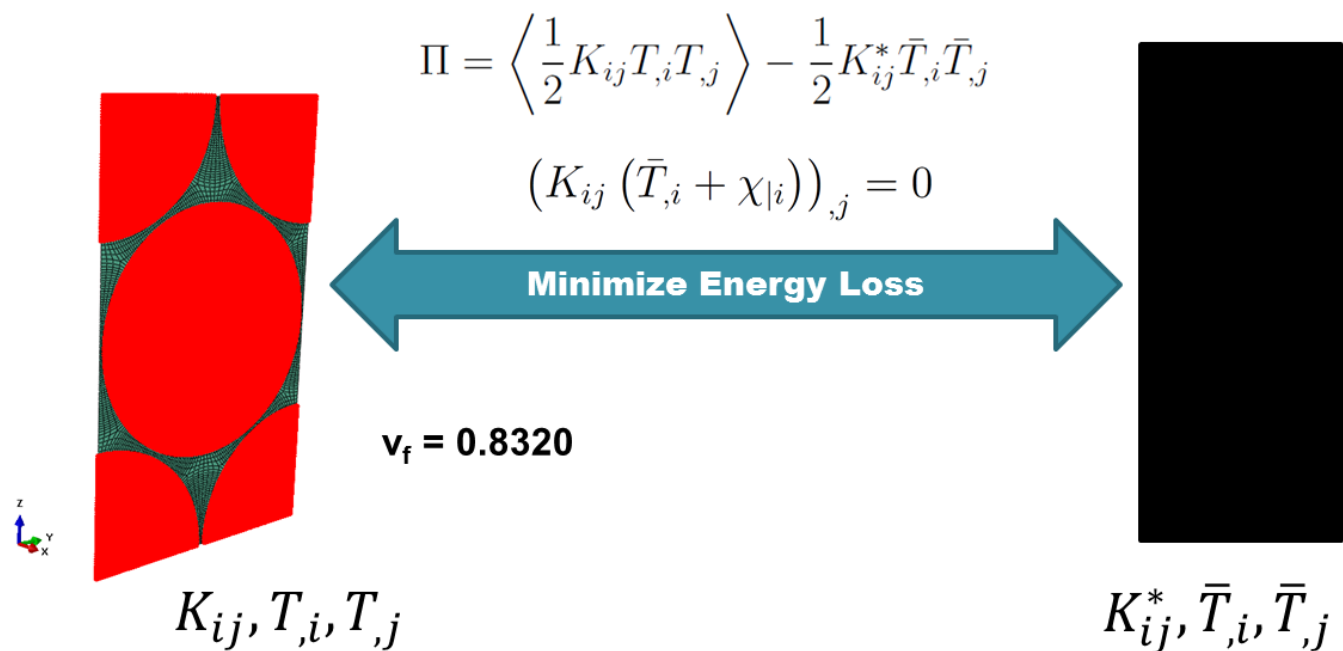
Problem Description

Homogenization Problem

In this example, isotropic matrix and transversely isotropic fiber are considered as constituent materials and we want to compute the effective thermal conductivity of the composite material. The corresponding material properties that we will use are defined in the following table.

Resin Conductivity, k_r	0.29 W/m/K
Fiber Conductivity in Fiber Direction, k_{f11}	6.83 W/m/K
Fiber Conductivity in Transverse to the Fiber Direction, k_{f22}	2.60 W/m/K

We will use a hexagonal pack with fiber volume fraction equal to $v_f = 0.8320$



Homogenization process

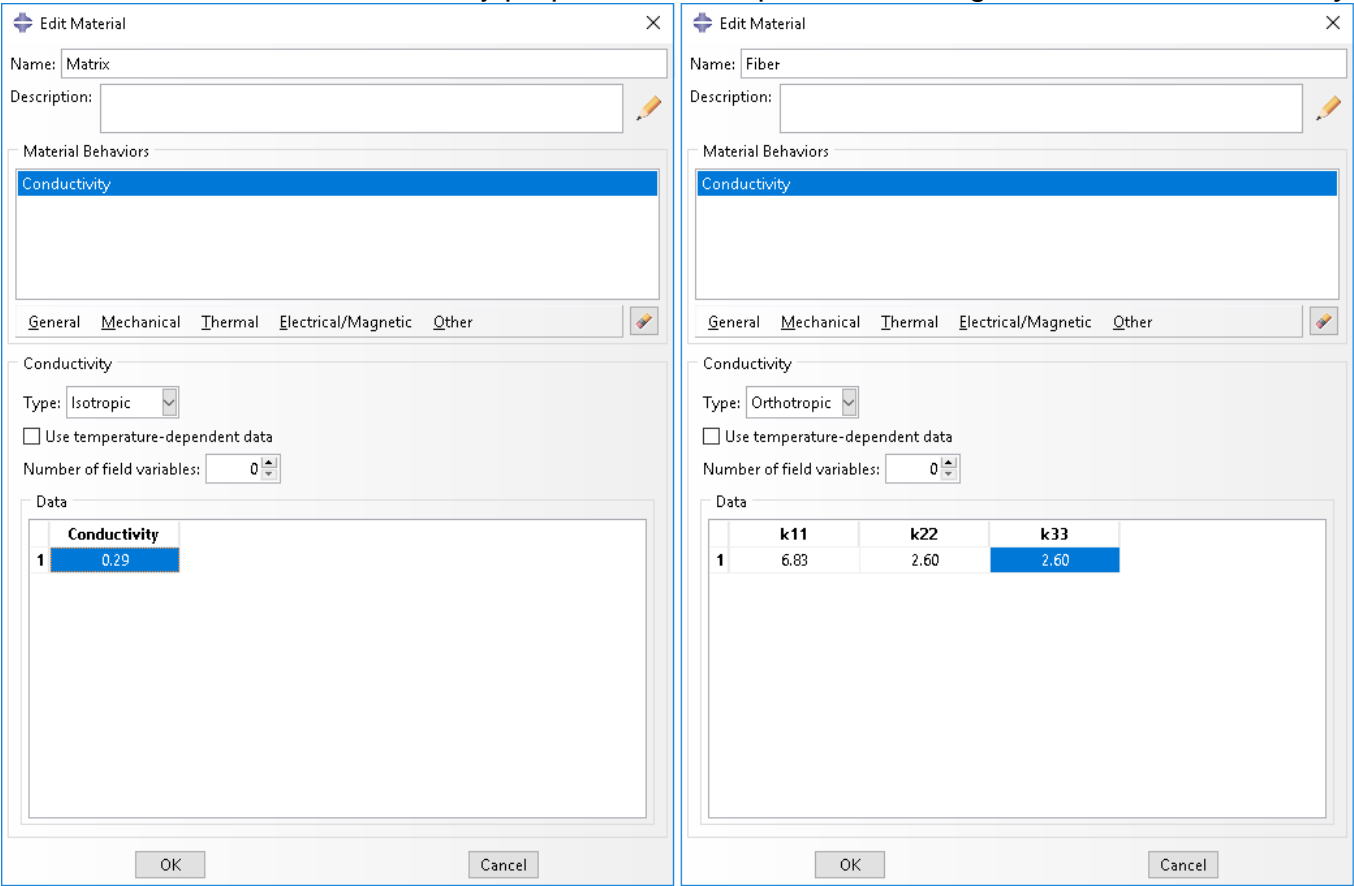
Software Used

In his tutorial we will use Abaqus CAE with the Abaqus [SwiftComp](#) GUI plug-in. Abaqus CAE will be used to define the material properties and Abaqus [SwiftComp](#) GUI to define the different structure genomes (SGs). [SwiftComp](#) will run in the background.

Solution Procedure

The steps required to compute the effective thermal conductivity using Abaqus [SwiftComp](#) GUI are as follows.

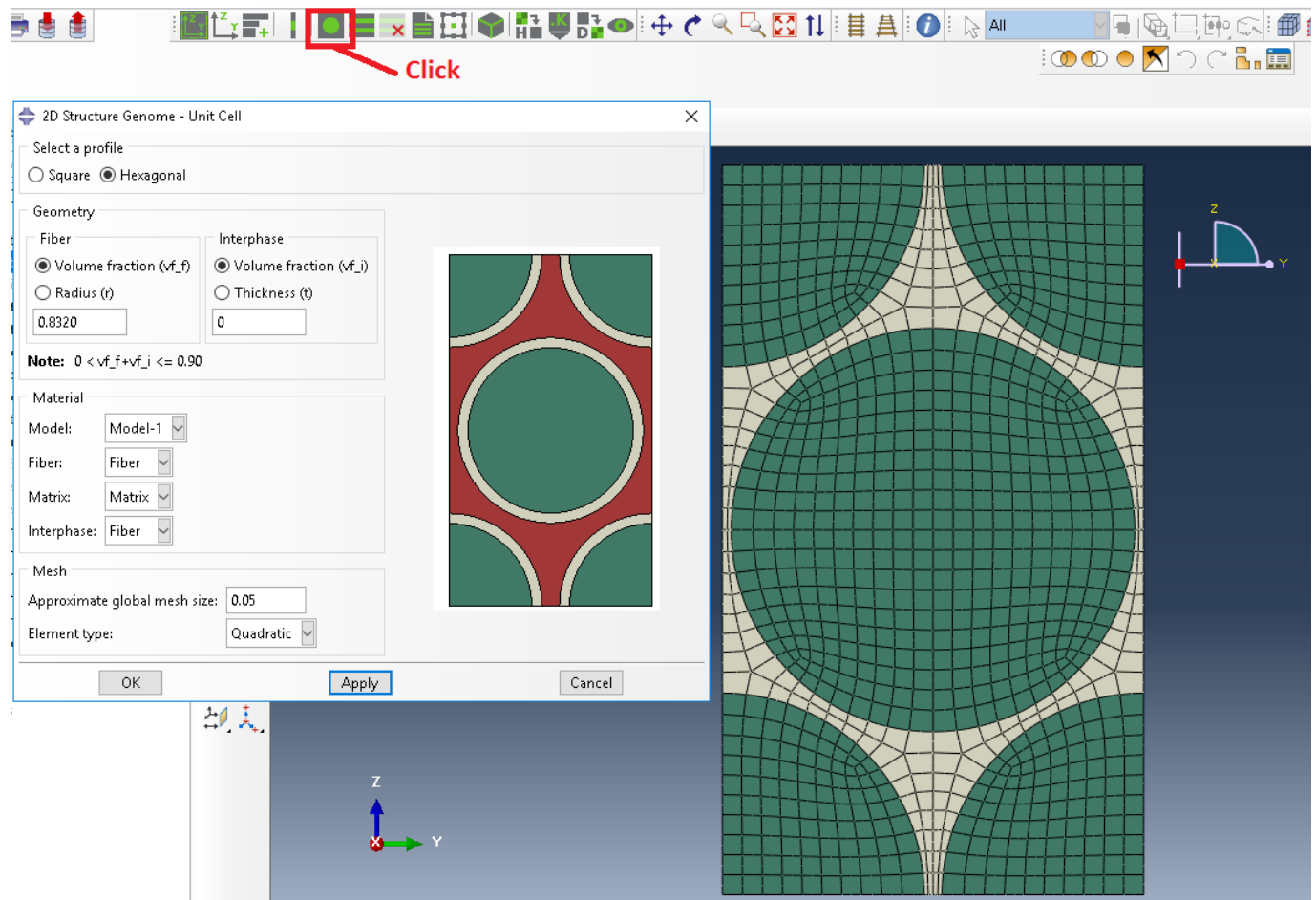
Step 1. We define the material properties in global coordinate system. In this case, we only need to define thermal conductivity properties in Abaqus CAE clicking on *Thermal, Conductivity*.



Definition of thermal conductivity as constituent properties

Step 2. From the default the Abaqus [SwiftComp](#) GUI SGs, we pick the 2D Structure Genome with Hexagonal pack.

COMPUTATION OF EFFECTIVE THERMAL CONDUCTIVITY WITH ABAQUS SWIFT COMP GUI



Definition of the 2D SG hexagonal pack microstructure

Step 3. Now, in order to compute the homogenized thermal conductivity properties, we click on *Homogenization* and we select *Conduction* in Analysis Type.

Homogenization

☐ New SwiftComp file name:

Model source

☒ CAE ☐ Input file

Model: Part:

Macroscopic model

Dimension

☐ 1D (Beam)
☐ 2D (Shell)
☒ 3D (Solid)

Dimensionally reducible structures

Specific model:

☐ Omega:

Note: Provide omega if the combination of structural model and structure genome is NOT any of the following cases:
1) 3D solid model with regular structure genome (rectangular for 2D and cuboid for 3D);
2) 2D shell model with 1D structure genome;
3) 1D beam model with 2D structure genome.
Please refer to the SwiftComp manual for more details.

Options

Analysis type: **Step 3**

Element type:

Elemental orientation:

Temperature distribution:

Aperiodic

☐ y1 ☐ y2 ☐ y3

☐ Only generate input file. Do not run SwiftComp.

Step 4

Definition of the homogenization step

Step 4. We click on *Ok* to run the homogenization step. [SwiftComp](#) on the background will run the homogenization.

```

Intel(R) MPI Library 2017 Update 3 for Windows* Target Build ...

*****
*                               SwiftComp  2.1                               *
*                               *                               *
*      Multiscale Constitutive Modeling of Composites                      *
*                               *                               *
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*****

SwiftComp begins at  161121.426
Inputs echoed in file hexP2_nSG2_3D_S8Rpbk.sc.ech!

Constitutive modeling for a 3D model!

Homogenization will be carried out!

You are running SwiftComp with full integration!

Finished reading/processing model file!

Effective properties can be found in file hexP2_nSG2_3D_S8Rpbk.sc.k!

Finished homogenization!

SwiftComp ends at  161121.614
SwiftComp finished successfully!

```

SwiftComp

running on the background

Step 5. The results can be found in the `.sc.k` file as shown next. Note that the first matrix corresponds to the effective thermal conductivity matrix in the form of K_{ij}^* . The second matrix corresponds to the compliance matrix in the form of $(K_{ij}^*)^{-1}$.

```
hexP2_nSG2_3D_S8Rpbcs.sc.k
1 The Effective Stiffness Matrix
2 -----
3 5.7312758E+00 0.0000000E+00 0.0000000E+00
4 0.0000000E+00 1.5043834E+00 -3.9399052E-16
5 0.0000000E+00 -3.9399052E-16 1.5043833E+00
6
7 The Effective Compliance Matrix
8 -----
9 1.7448122E-01 0.0000000E+00 0.0000000E+00
10 0.0000000E+00 6.6472414E-01 1.7408795E-16
11 0.0000000E+00 1.7408795E-16 6.6472420E-01
12
13
14 Effective Density = 0.0000000E+00
15
```

length: 733 | Ln: 15 Col: 1 Sel: 0 | 0 Windows (CRLF) UTF-8 INS

Results corresponding to the effective thermal conductivities

References

1. Rique, O.; Barocio, E.; Yu, W.: "Experimental and Numerical Determination of the Thermal Conductivity Tensor for Composites Manufacturing Simulation," ASC 32nd Technical Conference, October 2017, Purdue University.