THE UNIVERSITY OF TENNESSEE KNOXVILLE

Fracture Mechanics Term Project

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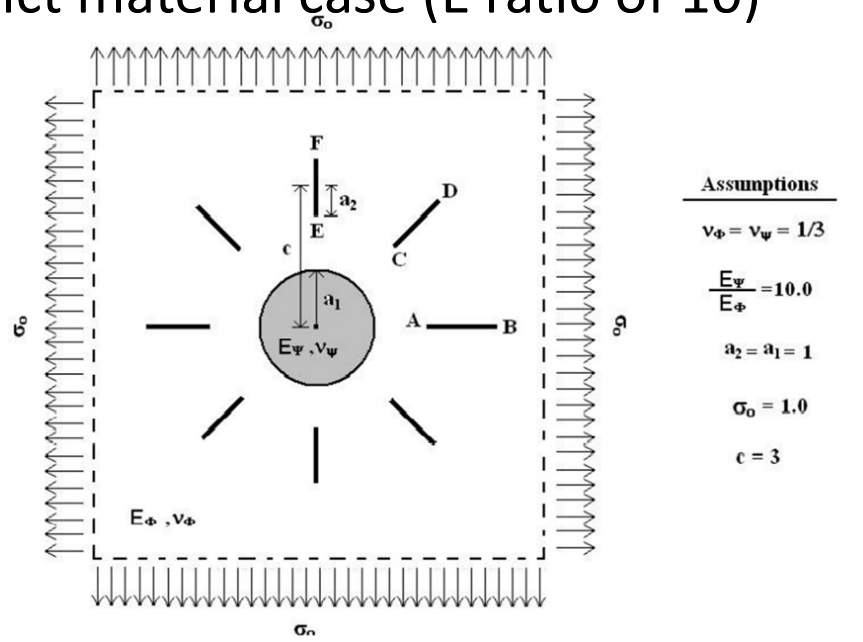
Interaction of Inclusion and Crack by Determination of the Stress Intensity Factor

- In the following problem, which is illustrated in Figure 1, compute stress intensity factors at all crack tips denoted as A-F and fill out Table 1. These stress intensity factors are modified by the effect of an inclusion of different elastic material on the stress state around a crack in an infinite plate (with plane stress state) subjected to tensile loading. The cases without inclusion means that the whole domain has the material properties of the matrix. The Elastic Modulus of the matrix, $E\phi$, is equal to 10e3 MPa. Use consistent units of N & mm, respectively for Force and Length, resulting in MPa for stress unit.

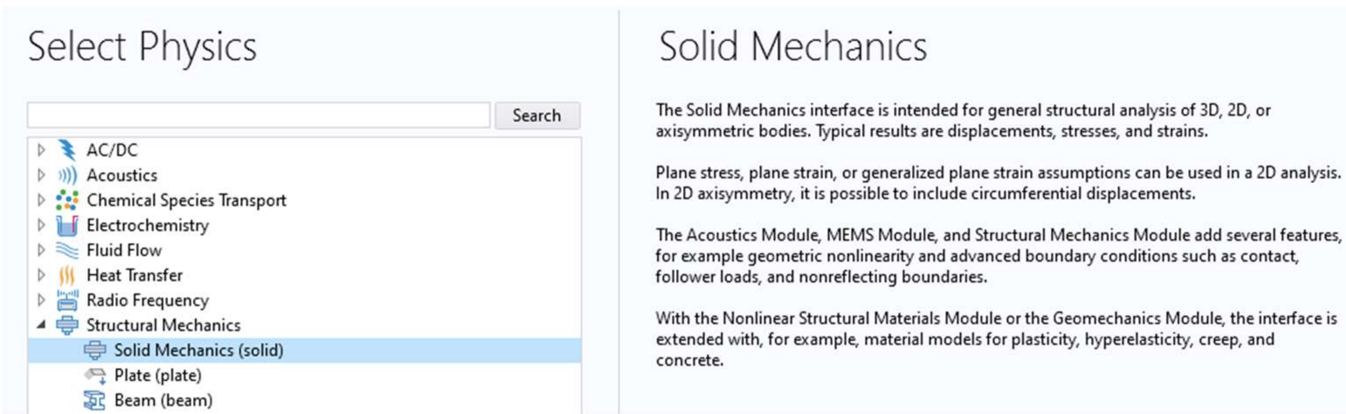
Tasks:

- 1. Compute J-integral for crack tip C.
- 2. Include figures of the partitioned area, mesh and the deformed shape around the crack region for distinct material case (E ratio of 10) with your final report.
- 3. Fill out table 1.



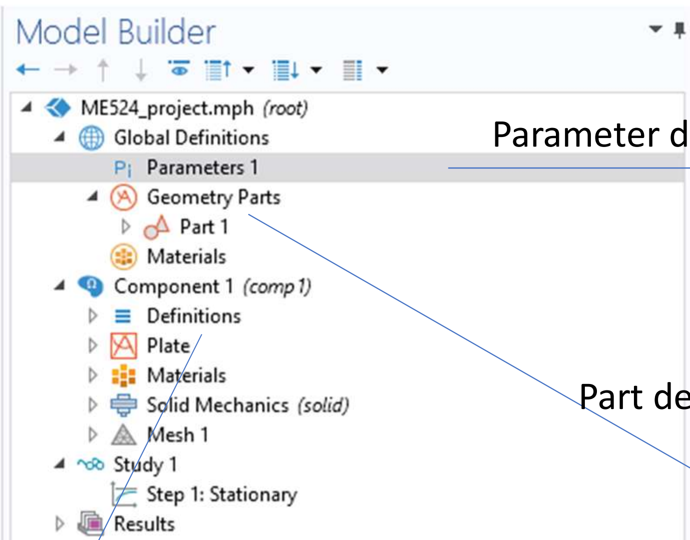
Modeling the problem

- We will use COMSOl for the computational project.
- After creating a blank project, 2D simulation is selected. Then we select Solid Mechanics



Defining the parameters

- Main menu shown below



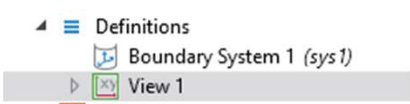
Parameter definition menu

Parameters

Name	Expression	Value	Description
a	1[mm]	0.001 m	Half crack length
c	3[mm]	0.003 m	Crack center distance
E_phi	10e3[MPa]	1E10 Pa	E of the matrix
E_ksi	10*E_phi	1E11 Pa	E of the inclusion
nu_1	1/3	0.33333	Possion's ratio
sigma_0	1[MPa]	1E6 Pa	Far field load
L	15[mm]	0.015 m	Domain size

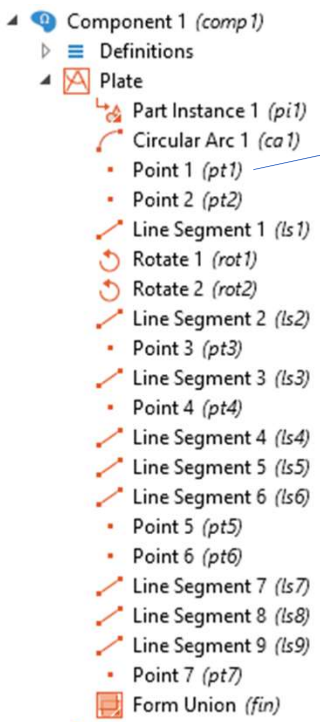
Part definition: Creating a square as infinite domain

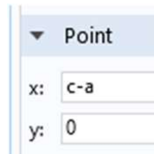
Definitions (coordinate system etc. generated automatically)



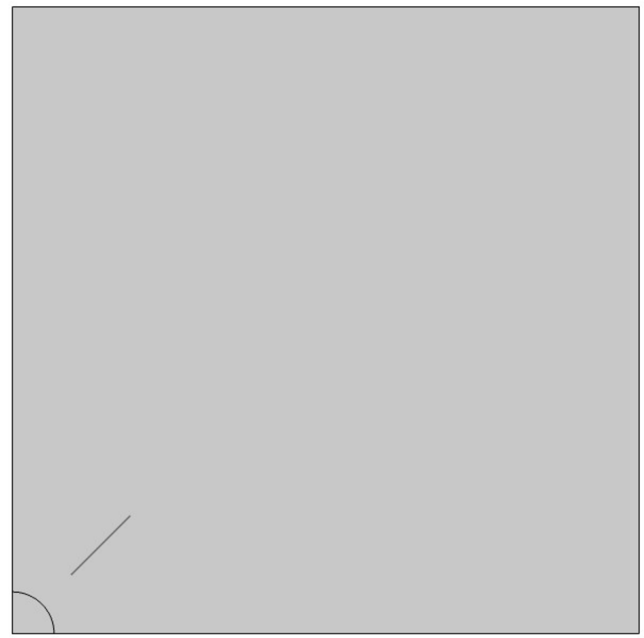
Geometric definitions

Following components are defined:



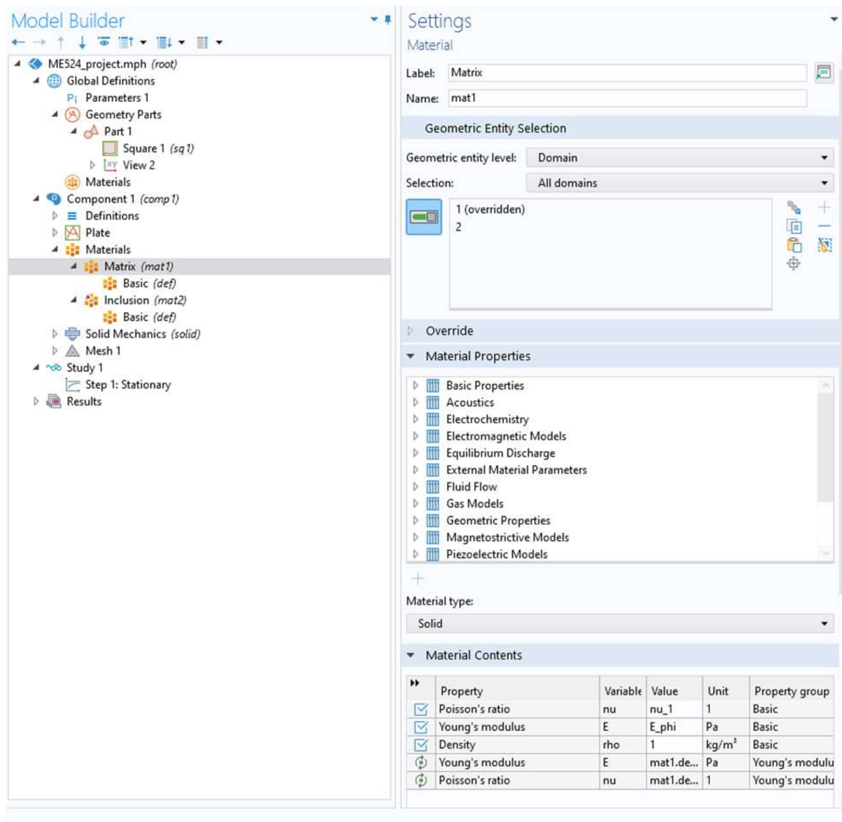


e.g. parameter usage

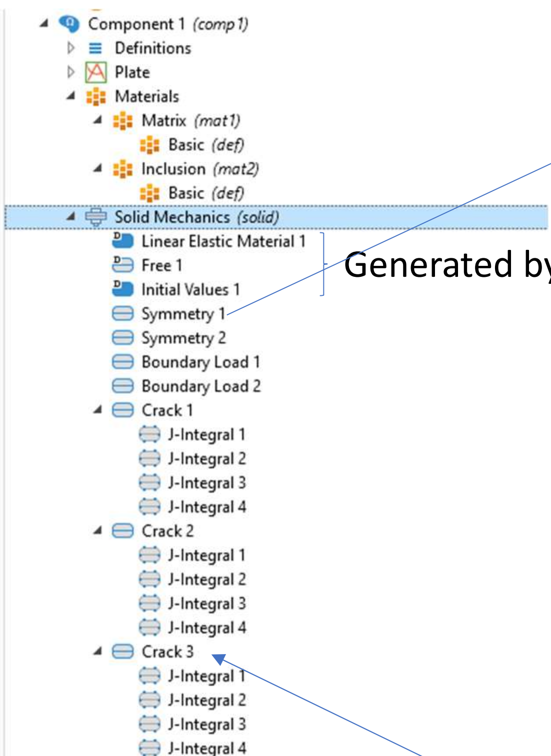


Material definitions

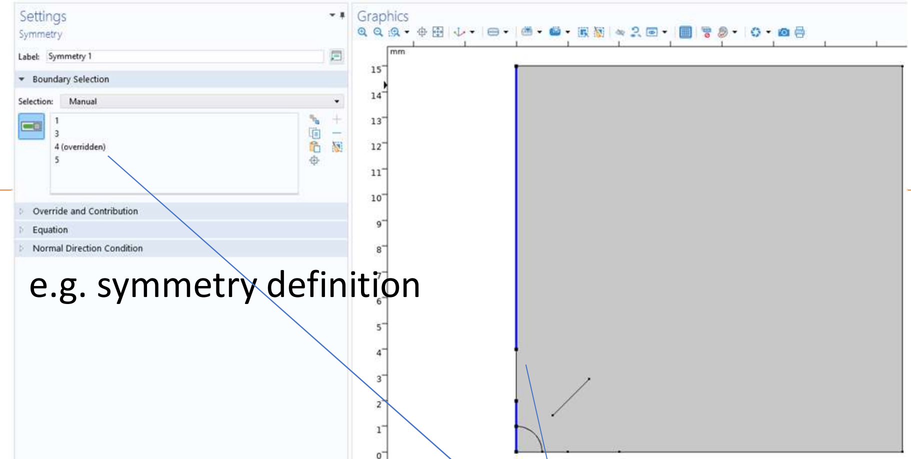
- Materials are defined using the parameters inputs we defined earlier



Physics definitions

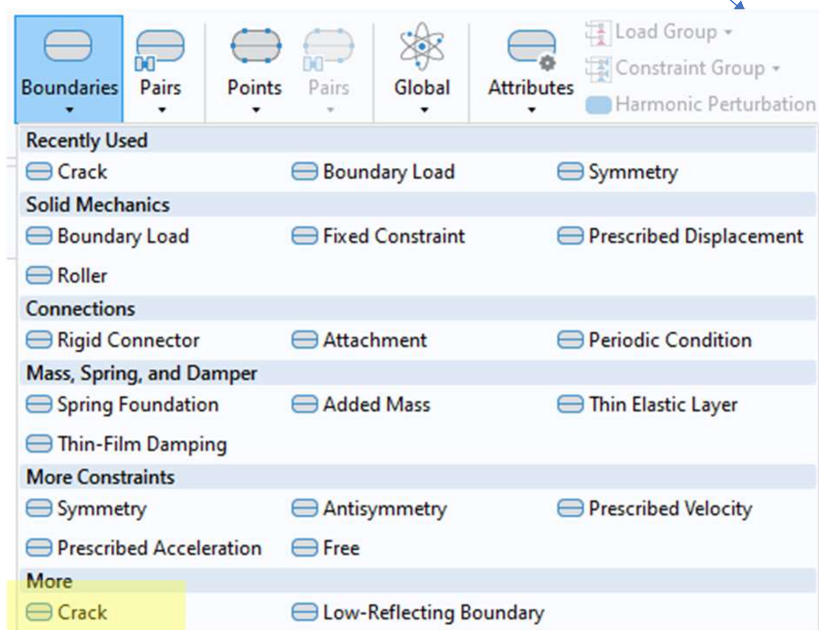


Generated by default

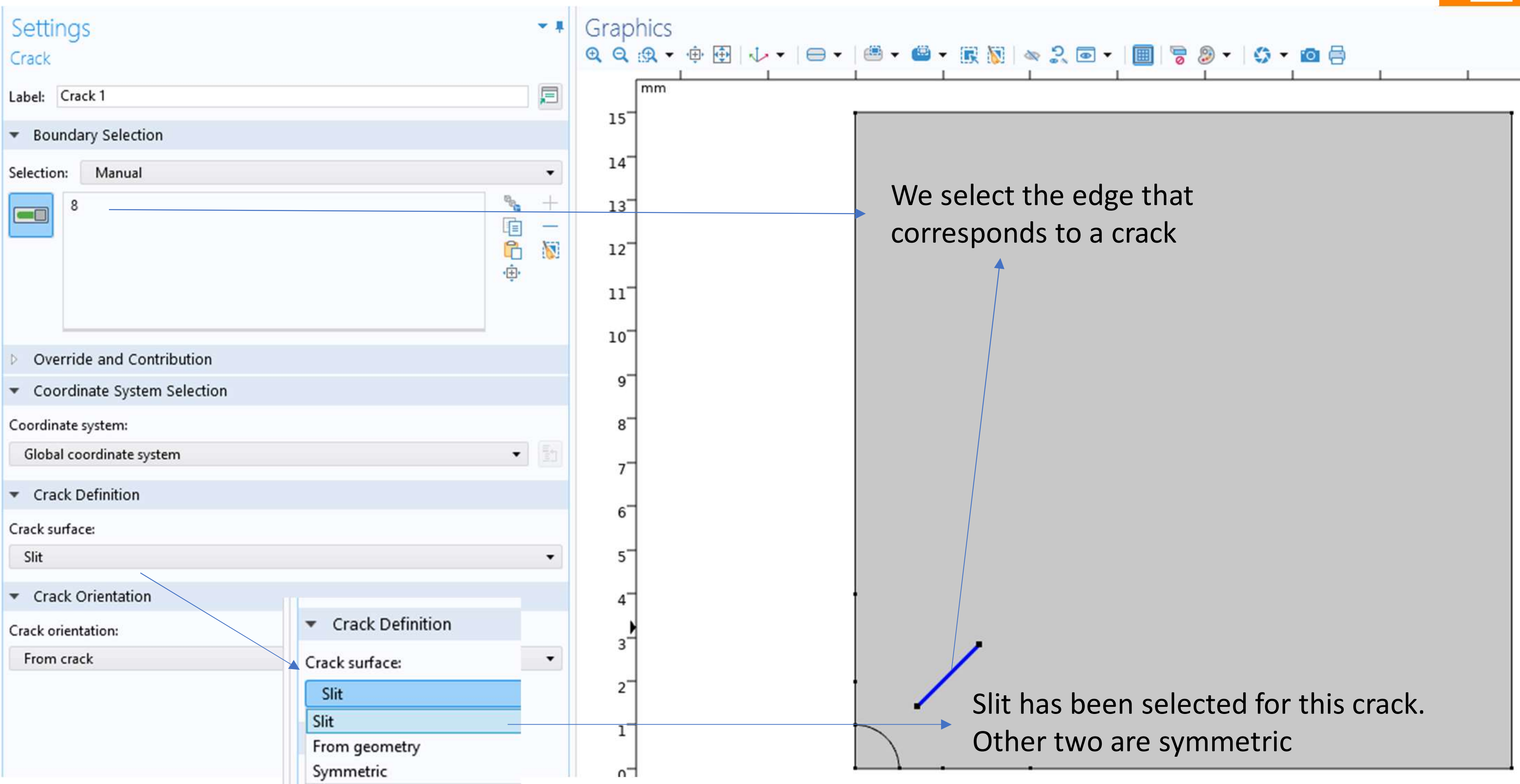


e.g. symmetry definition

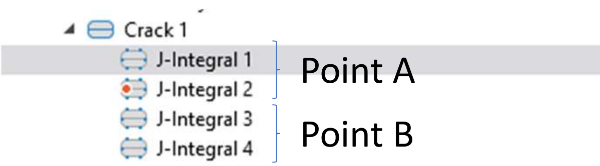
Overwritten since we defined a crack to that boundary



Defining crack



J-integral definition



Point A

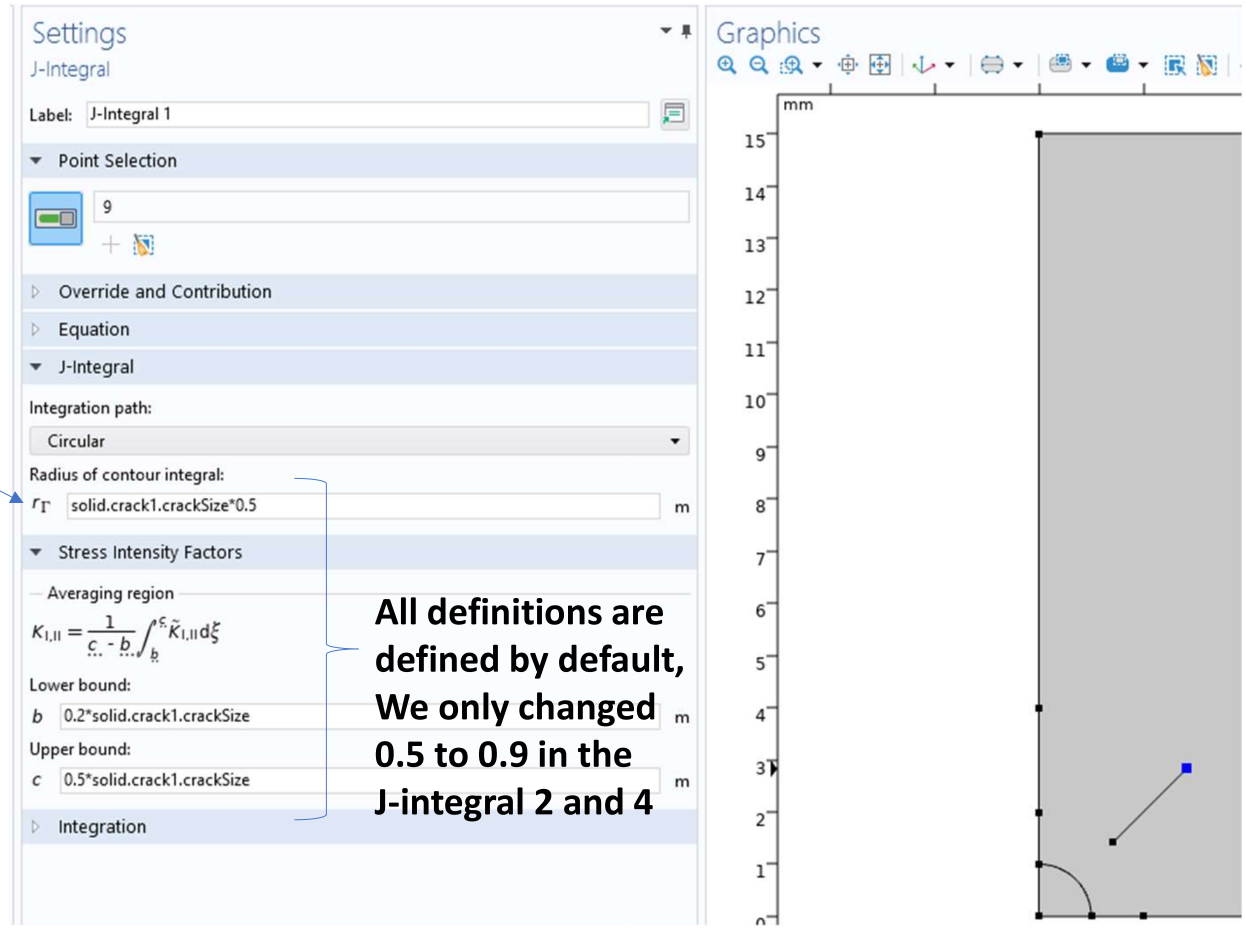
Point B

The reason for having two J-integrals, we have two different radius for the contour integral

For this case it is 0.5 of the crack size,

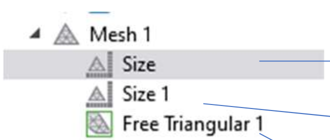
We also calculate for 0.9 crack size

(results were very similar, 0.5 results have been used)



All definitions are defined by default, We only changed 0.5 to 0.9 in the J-integral 2 and 4

Meshing

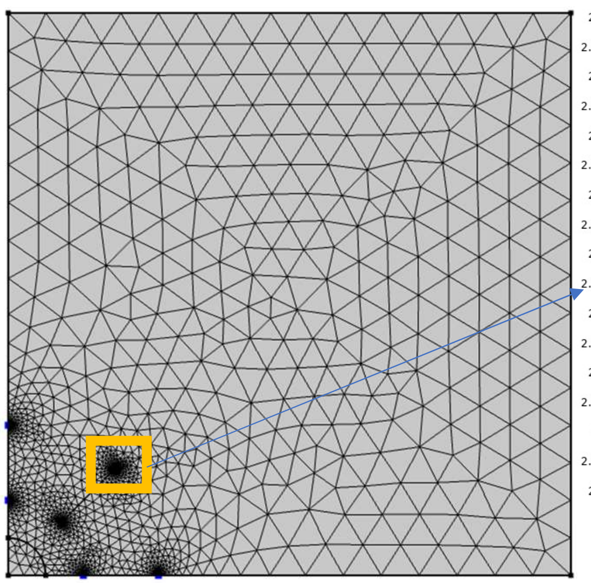


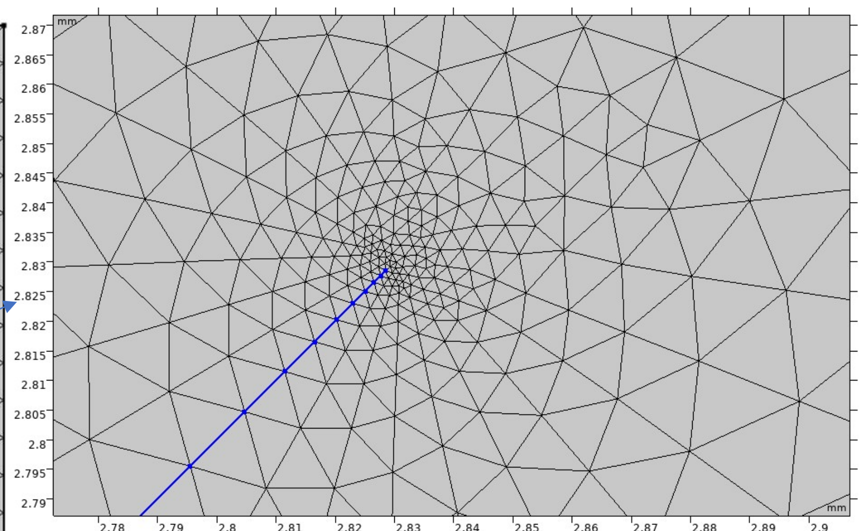
Default mesh size for all domain

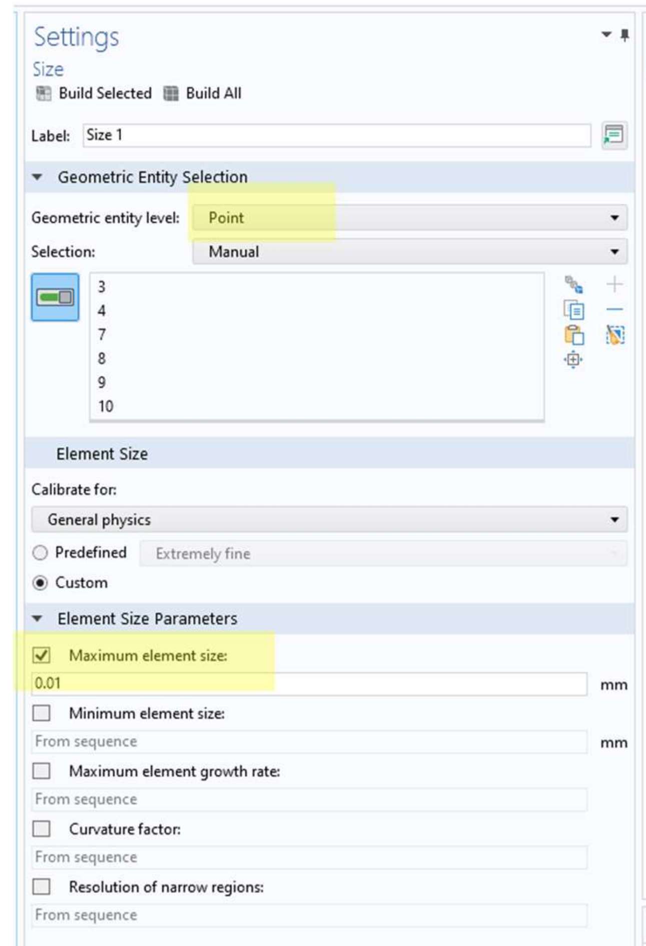
Refinement around the corners

Mesh generator

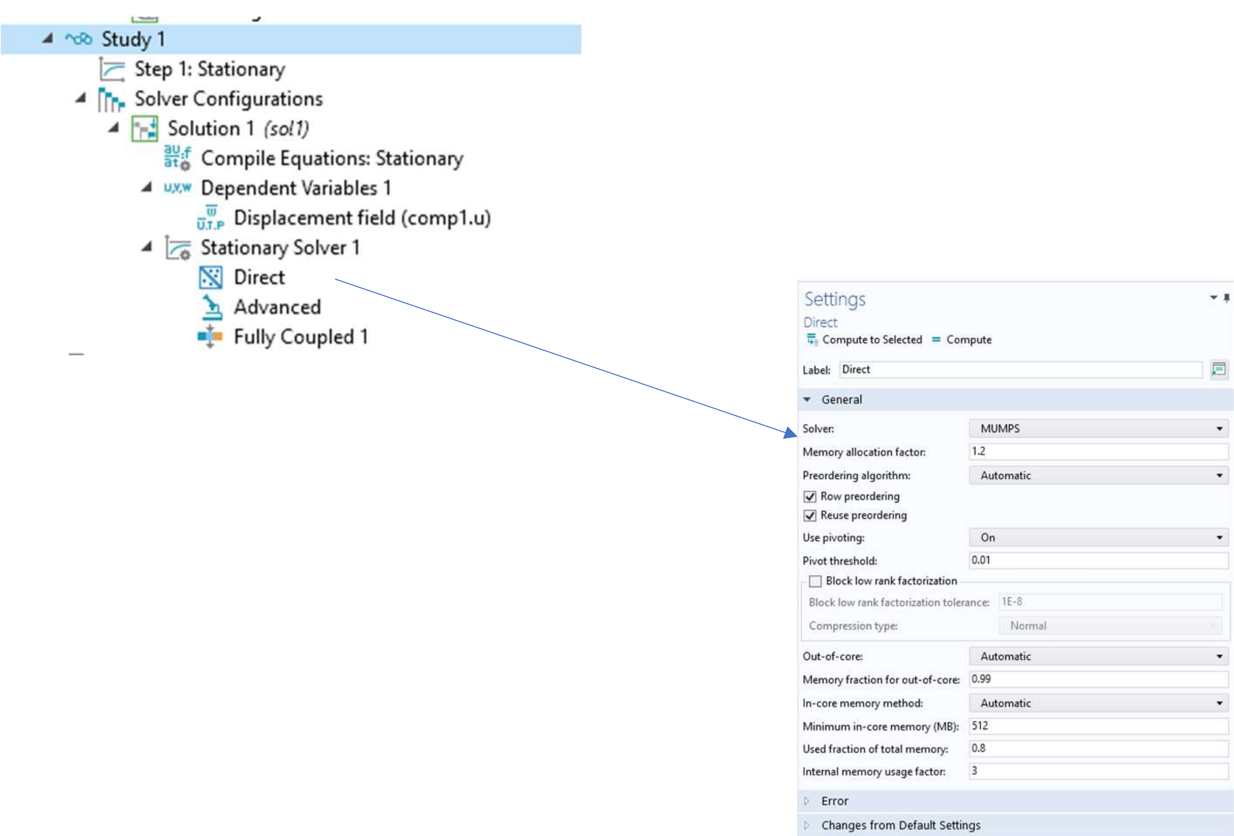
Resulting mesh





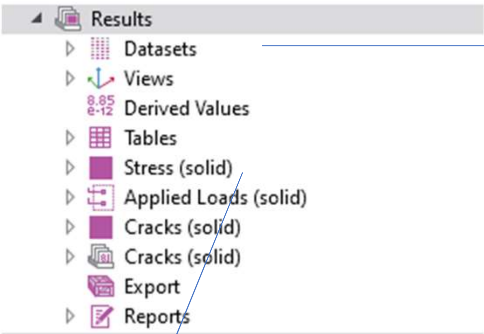


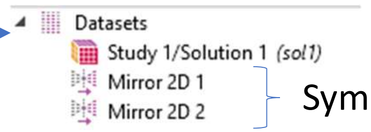
Solver configuration



All parameters are default in this section.

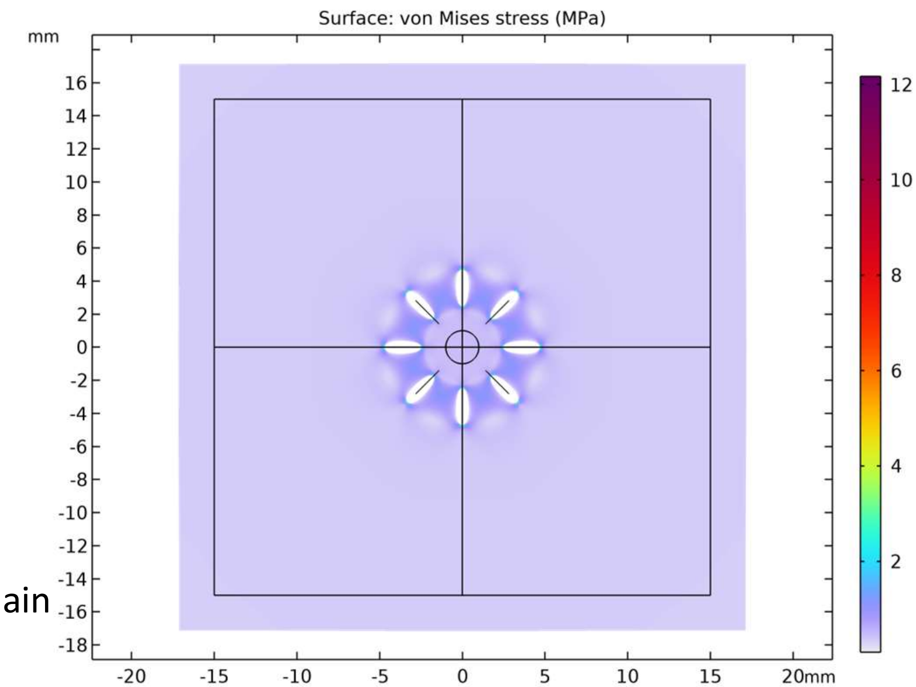
Results

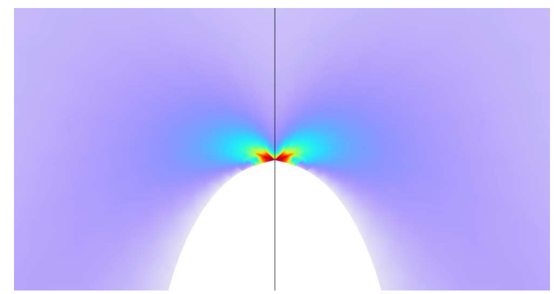




Symmetries are recovered visually by defining mirrors

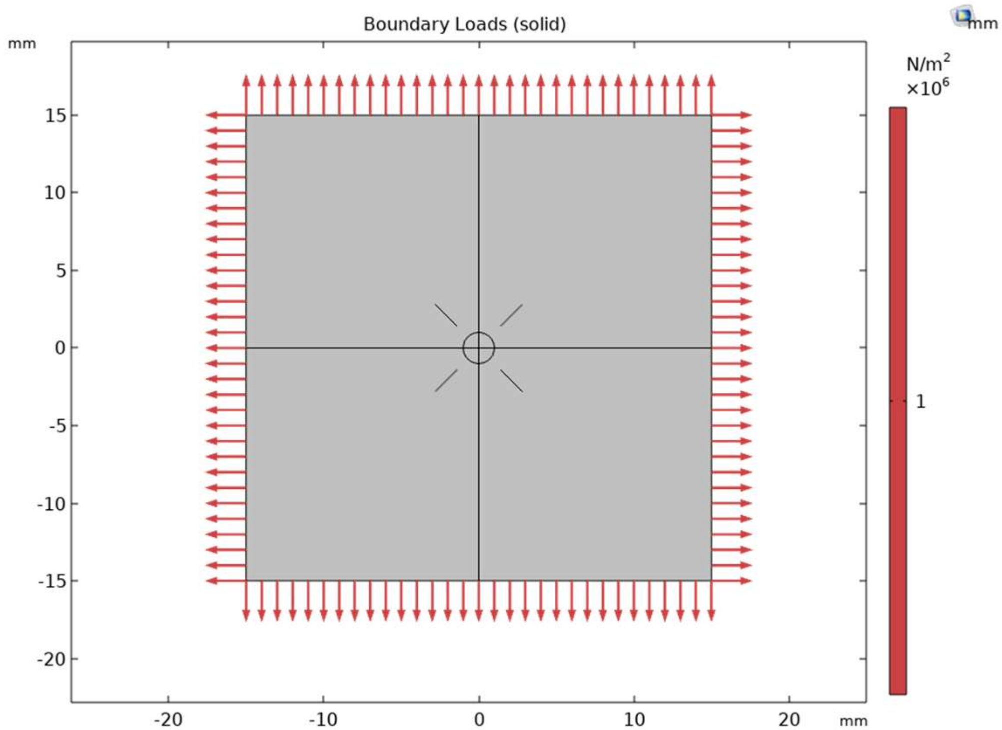
Mirror is selected to plot the domain

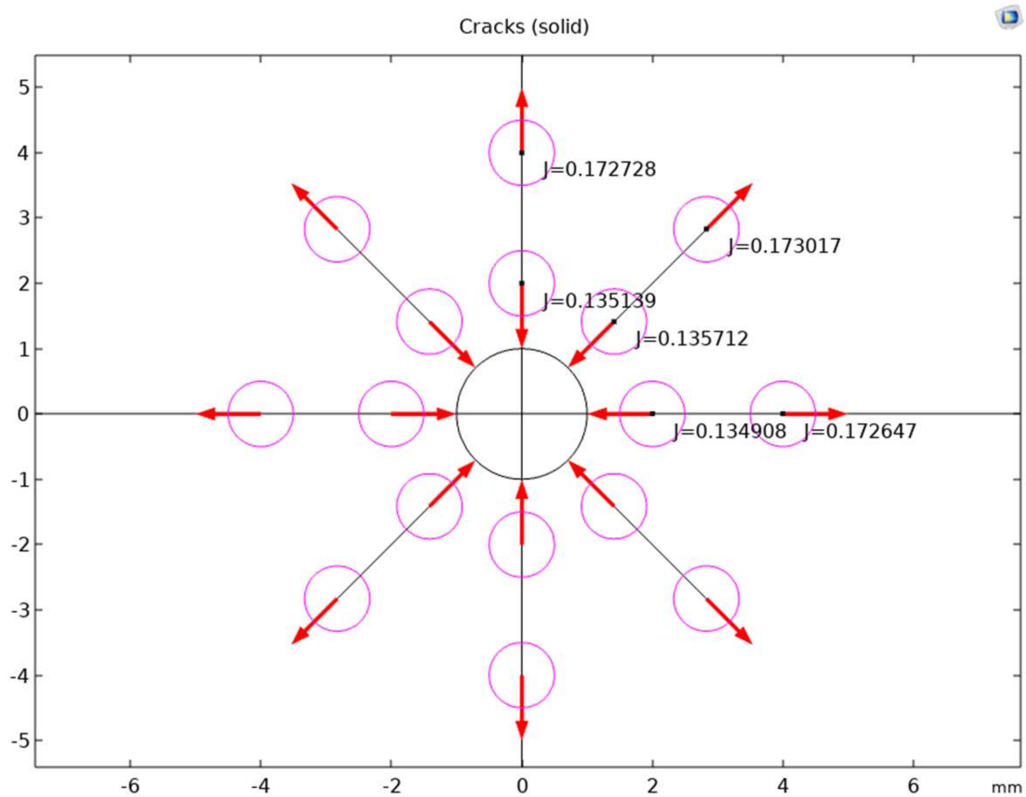




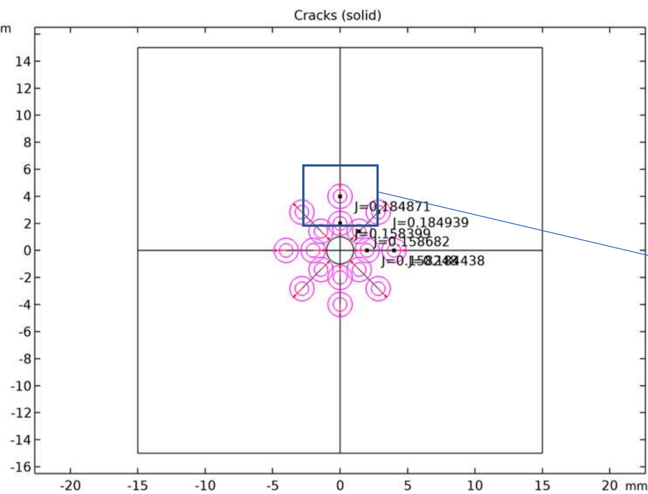
Boundary Loads and cracks

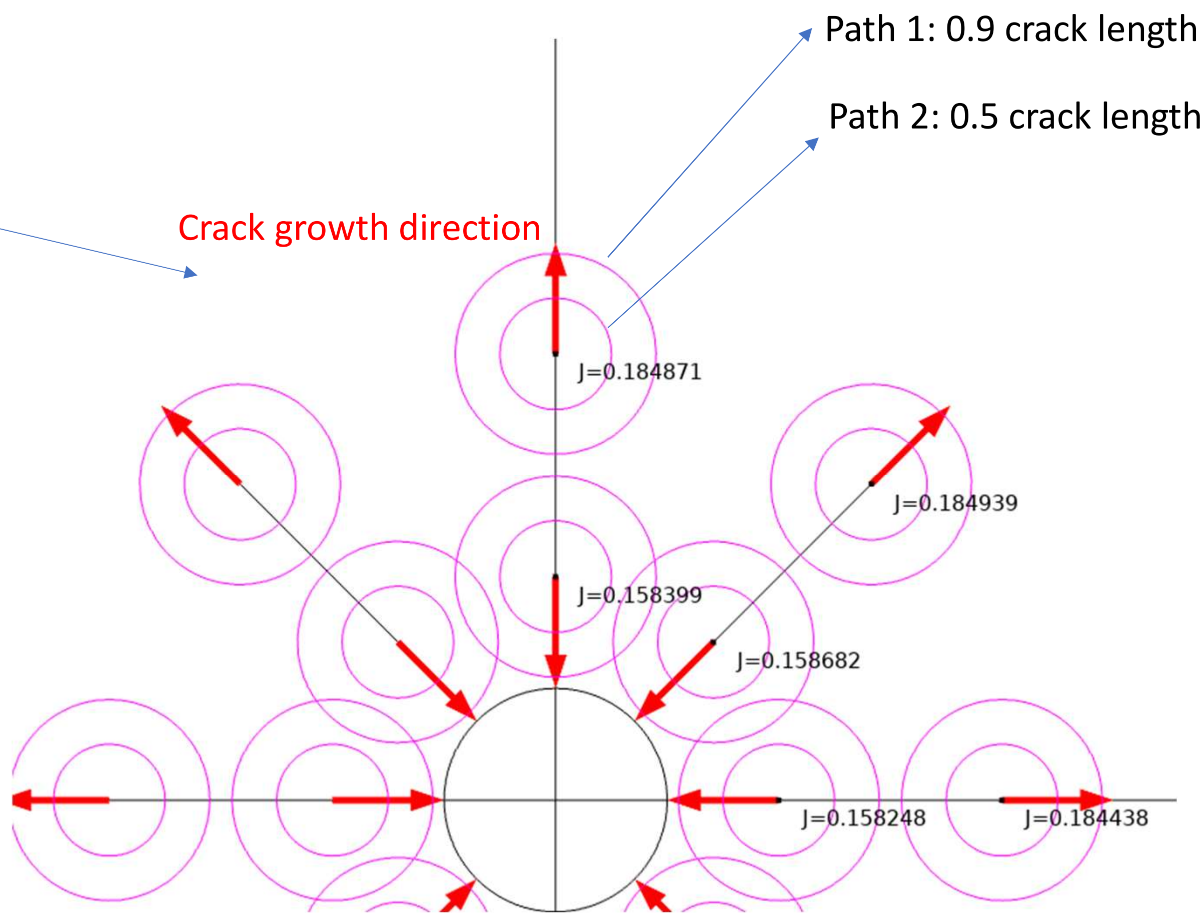
J-integral at point C = 0.13571 J/m^2



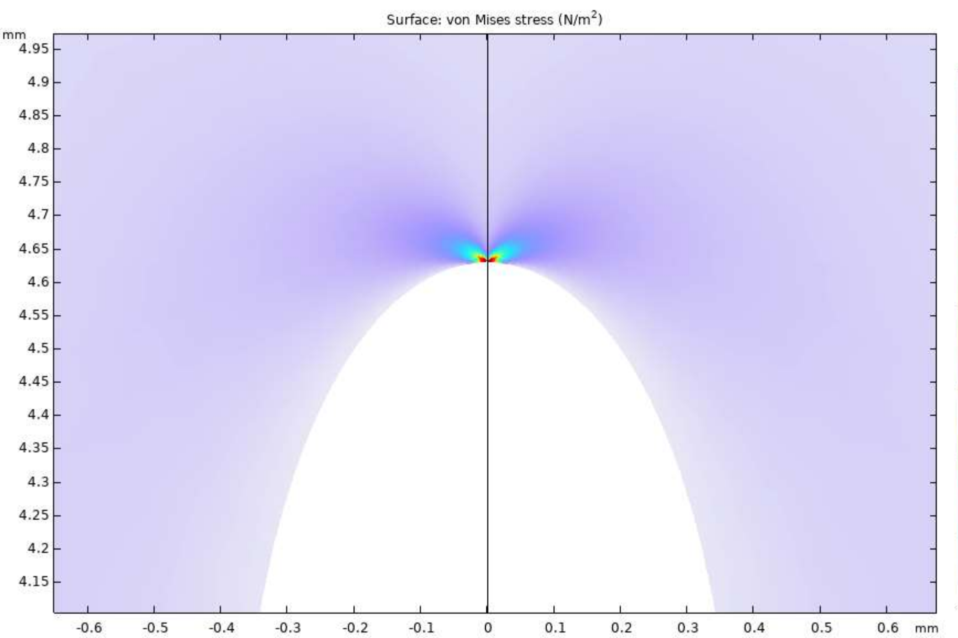


Cracks

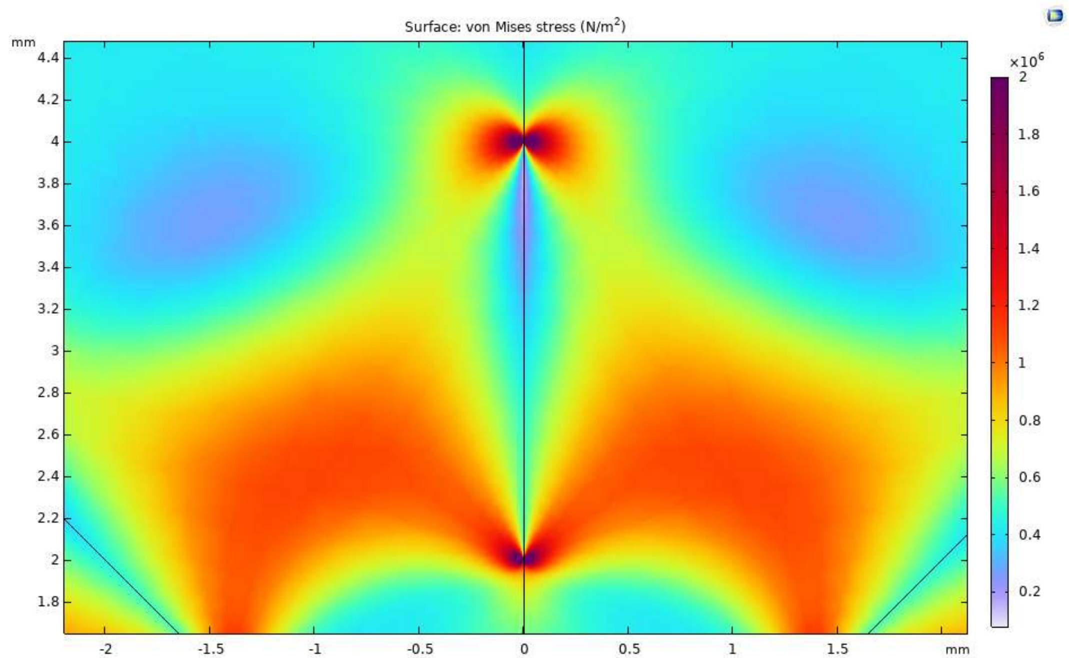

Cracks (solid)
J=0.184871
J=0.184939
J=0.158682
mm


Path 1: 0.9 crack length
Path 2: 0.5 crack length
Crack growth direction
J=0.184871
J=0.184939
J=0.158399
J=0.158682
J=0.158248
J=0.184438

Stress plot around crack



Deformation is scaled

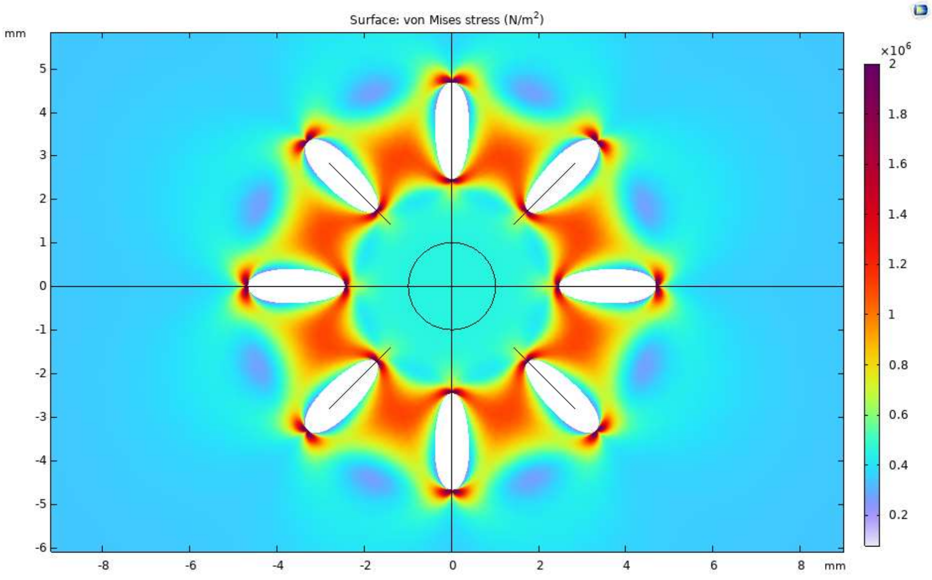


Deformation is not scaled

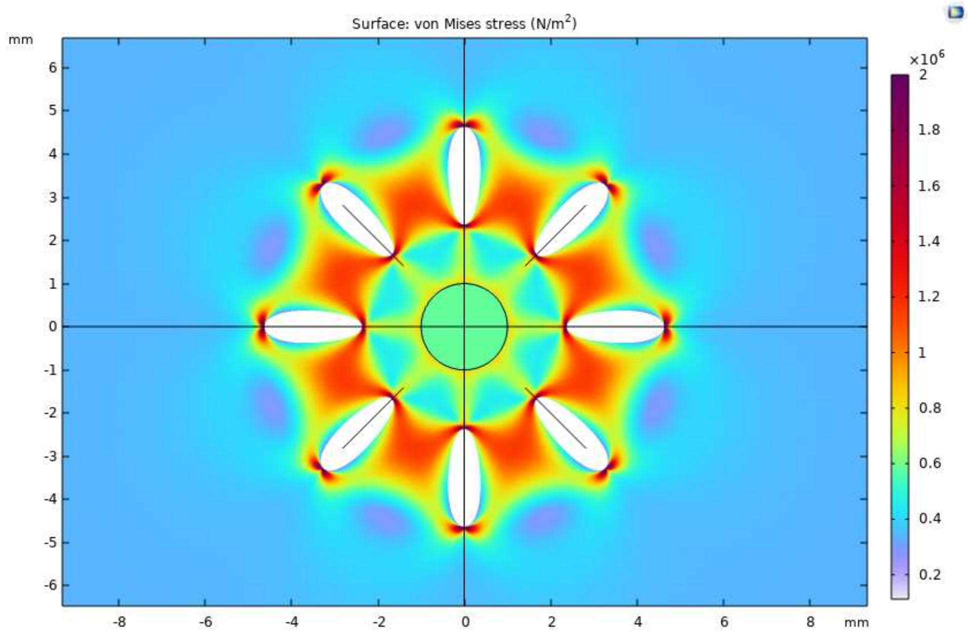
Far field v-M stress = 0.33 MPa
v-M stress at the angled crack = 26.7 Mpa
v-M stress at the vertical crack = 36.3 MPa

Stress plots

Matrix only



Matrix + Inclusion



Matrix only results

Crack tip	J-integral (J/m^2)	K_I (MPa/mm^1/2)	K_II (MPa/mm^1/2)
A	0.15826	42195	0
B	0.18492	45611	0
C	0.15904	42299	0.31425
D	0.18537	45667	-0.83114
E	0.1585	42227	0
F	0.185	45621	0

Numerical error

Matrix + Inclusion results

Crack tip	J-integral (J/m^2)	K_I (MPa/mm^1/2)	K_II (MPa/mm^1/2)
A	0.13491	38958	0
B	0.17265	44071	0
C	0.13571	39074	0.28458
D	0.17302	44118	-0.83295
E	0.13514	38991	0
F	0.17273	44082	0

Stiffer inclusion resulted lower stress intensity factors.