

## Plotting stress trajectories (principal stress lines) with CalculiX

Commercial finite element (FE) programs calculate principal stresses (PS)  $\sigma_1$  and  $\sigma_2$ , furthermore PS directions, but not the associated PS lines (PS trajectories). In engineering, important application areas are based on the knowledge of PS lines, e.g. composites with variable fiber placement, steel reinforcement in concrete, topology optimization. The following example shows that FE programs with analysis options for linear statics and orthotropic heat conduction allow the calculation and visualization of PS lines in the form of isotherms. The static calculation provides the PS directions, which serve as local systems for the orthotropic thermal conductivities  $k_1$  and  $k_2$  in the following heat conduction calculation. For extreme conditions with  $k_1/k_2 > 10^4$  the isotherms are tangent to the PS1 directions: The isotherms of a heat conduction calculation with extreme orthotropy simulate the PS lines.

The following example was tested with CalculiX 2.16 (Laucher 3.4) under Windows 10.

Example: Disc with hole under tension (1 MPa, quarter model)

- A) Run Static.inp -> Static.dat (it can be compared with Static.dat from TFP.zip)
- B) Compile Local.for. If you don't have a compiler, execute Local.exe. (You can compare the resulting 3 output files Elset.inp, Solid.inp, Orientation.inp with the corresponding files from TFP.zip)
- C) Run Heat.inp, plot temperature contour lines with Calculix CGX.