Evaluating Strain Results

Mechanical Strain in Deformation Analysis – Lesson 5

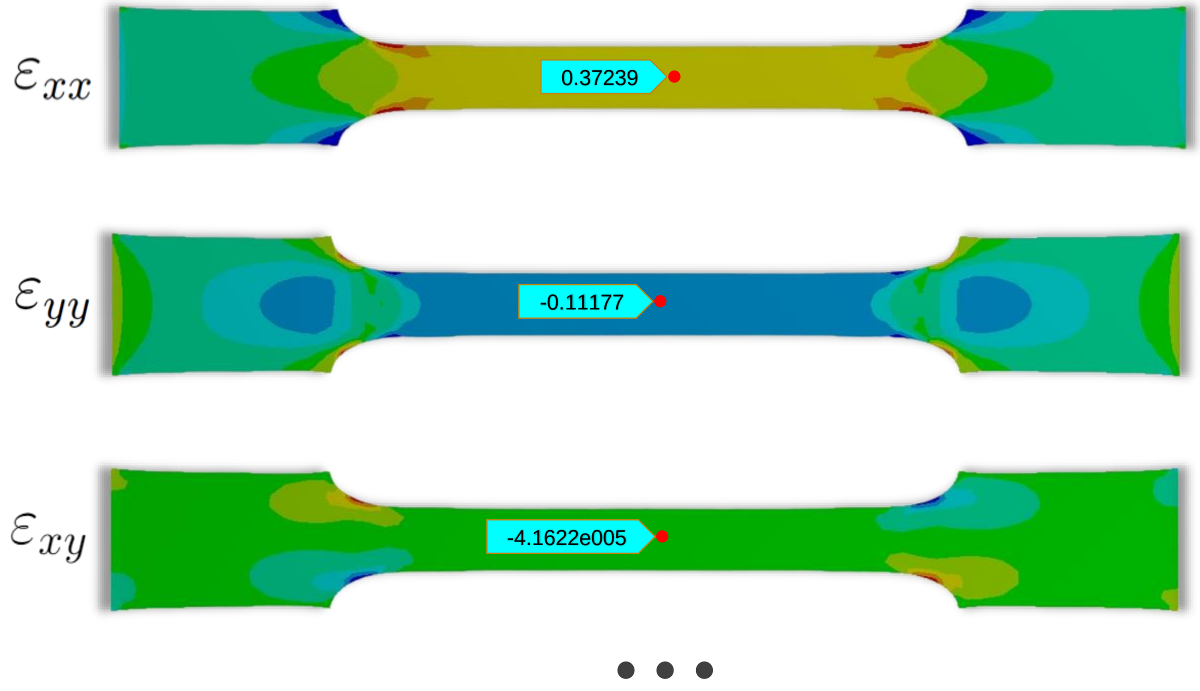
Ansys

Evaluating Strain Results

How can we evaluate a strain value after a mechanical problem is solved? We will be given strain value for each material point.

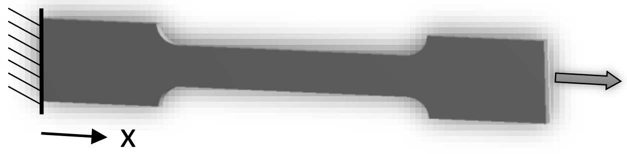
$$\begin{bmatrix} \varepsilon_{xx} & \varepsilon_{xy} & \varepsilon_{xz} \\ \varepsilon_{yx} & \varepsilon_{yy} & \varepsilon_{yz} \\ \varepsilon_{zx} & \varepsilon_{zy} & \varepsilon_{zz} \end{bmatrix}$$

- Each material point over the body has a strain state, which is recorded as a strain tensor.
- Each tensor has nine components.
- There will be nine contour plots, one contour plot for each strain component.



9 Contour Plots

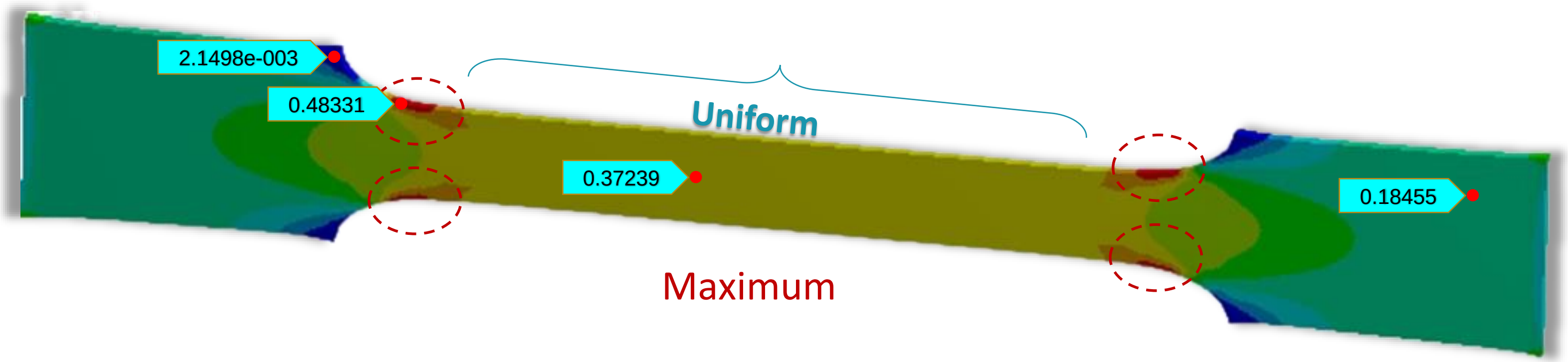
Evaluating Strain Results: Strain over a Body



A strain state is local. Each material point has a strain state. Let's have a look at some tensile test results from a specimen.

Tensile test analysis results: ε_{xx}

- Strain is almost uniform for the center area of the specimen.
- Strain value varies when the geometry becomes irregular (dashed red circles).

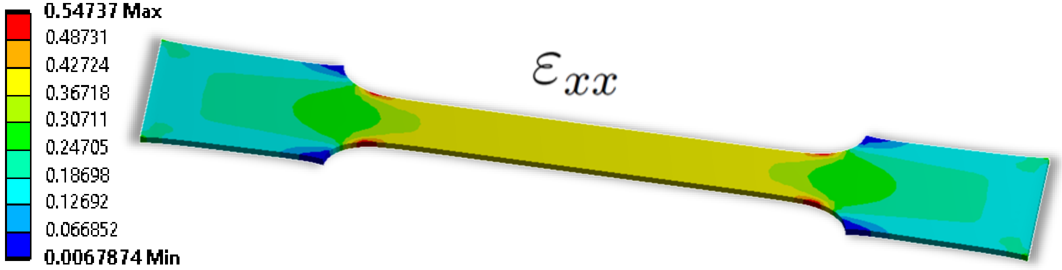


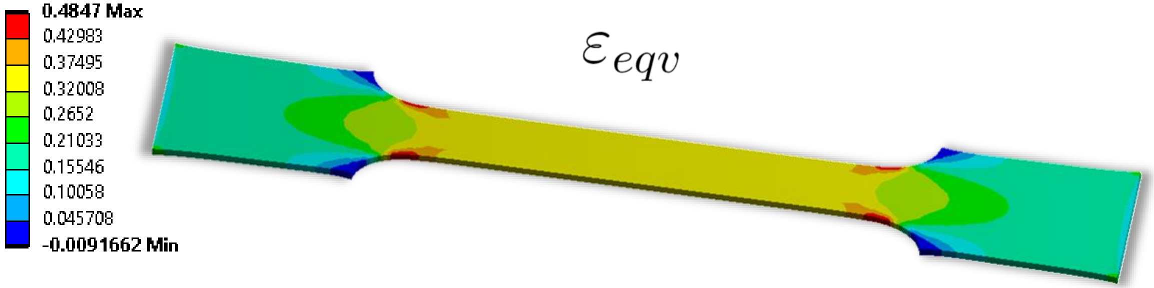
Evaluating Strain Results: Equivalent Strain

From a strain tensor, we can calculate the equivalent strain. Equivalent strain, as a scalar, is a straightforward variable to report strain results over a body, although it does not represent the complete information of the strain state.

$$\begin{bmatrix} \varepsilon_{xx} & \varepsilon_{xy} & \varepsilon_{xz} \\ \varepsilon_{yx} & \varepsilon_{yy} & \varepsilon_{yz} \\ \varepsilon_{zx} & \varepsilon_{zy} & \varepsilon_{zz} \end{bmatrix} \Rightarrow \varepsilon_{eqv} = \left(\frac{1}{1+\nu}\right)\sqrt{\frac{(\varepsilon_{xx}-\varepsilon_{yy})^2+(\varepsilon_{yy}-\varepsilon_{zz})^2+(\varepsilon_{zz}-\varepsilon_{xx})^2+6(\varepsilon_{xy}^2+\varepsilon_{yz}^2+\varepsilon_{zx}^2)}{2}}$$

ν is Poisson's ratio. Some definitions do not include this term.



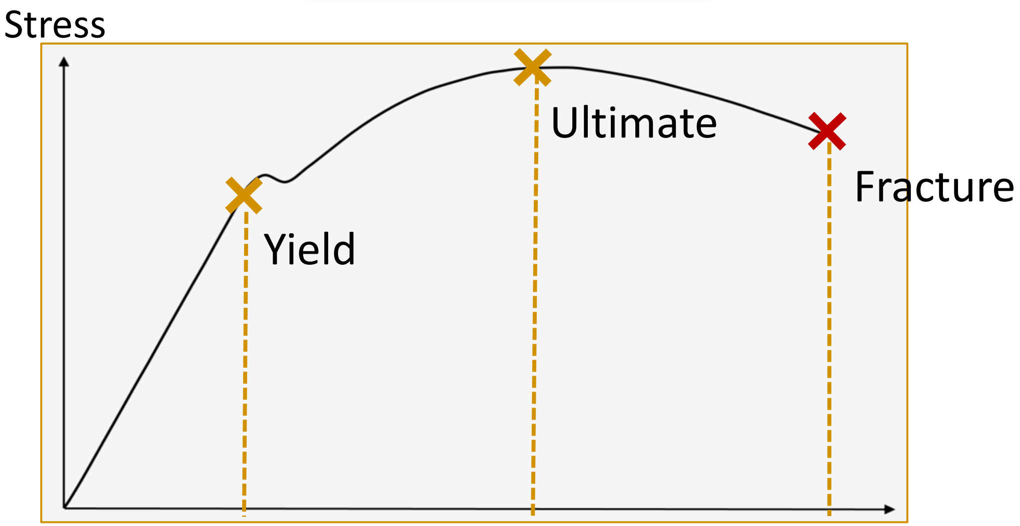


In this case, the distributions and values of equivalent strain and strain in the normal x direction are very similar, because deformation in the x direction is dominant in this tensile test.

Evaluating Strain Results: Material Failure

In mechanical design and analysis, it's common that an engineer needs to predict or recognize the failure of materials. The material failure point is not necessarily always the breaking point or facture point. Depending on design objectives, a material failure can be defined as occurring when the yield point or a certain amount of distortion is reached.

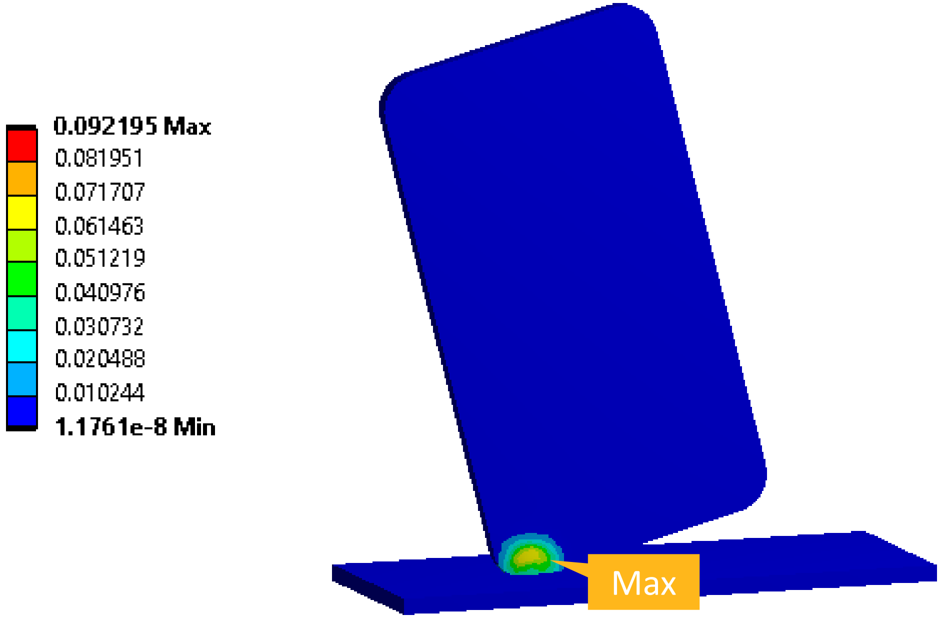
Material failure



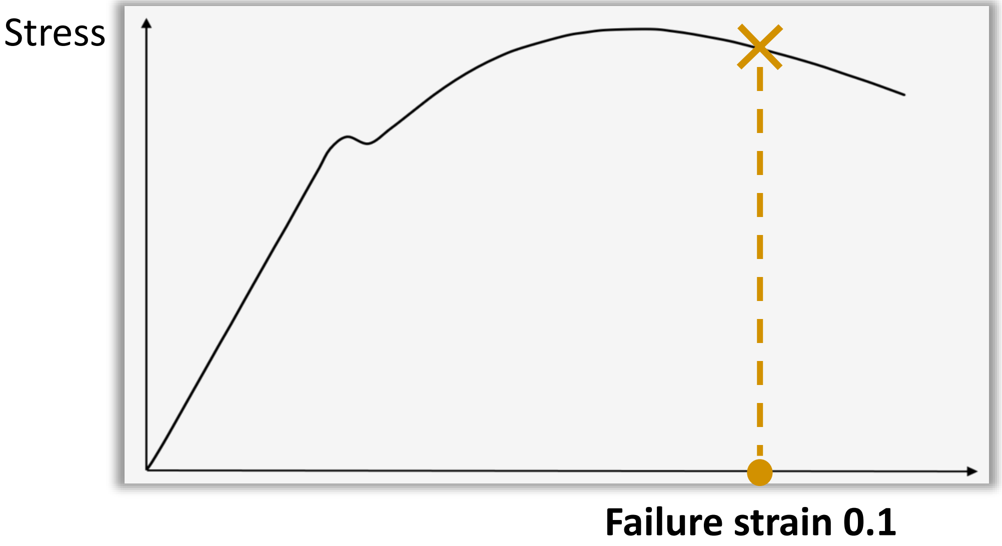
Strain

Evaluating Strain Results: Material Failure

Strain can be an indication of the critical failure location. It can be compared to the material failure strain value to determine if the material has failed or to the calculate strain safety factor.



Material failure



Check the strain result of the cell phone drop test analysis to decide if the material has failed.

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