Distortion-Energy Theory for Ductile Materials

The distortion-energy theory predicts that yielding occurs when the distortion strain energy per unit volume reaches or exceeds the distortion strain energy per unit volume for yield in simple tension or compression of the same material.

 The distortion-energy (DE) theory originated from the observation that ductile materials stressed hydrostatically (equal principal stress) exhibited yield strengths greatly in excess of the values given by the simple tension test. Therefore it was postulated that yielding was not a simple tensile or compressive phenomenon at all, but, rather, that it was related somehow to the angular distortion of the stressed element.

 For plane stress, the von Mises stress can be represented by the principal stresses $σ\_{A}$, $σ\_{B}$, and zero. We get

 $σ^{'}=(σ\_{A}^{2}-σ\_{A}σ\_{B}+σ\_{B}^{2})^{{1}/{2}}$

 Equation is a rotated ellipse in the $σ\_{A}$, $ σ\_{B}$ plane. The dotted lines in the figure represent the MSS theory, which can be seen to be more restrictive, hence, more conservative.

Using xyz components of three-dimensional stress, the von Mises stress for plane stress can be written as

 $σ^{'}=(σ\_{x}^{2}-σ\_{x}σ\_{y}+σ\_{y}^{2}+3τ\_{xy}^{2})^{{1}/{2}}$