Geometrical description of stress and strain tensor and its relation to material effort hypotheses

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A stress and strain tensor may be presented as a surface delimited by vectors located at angles α_1, α_2, α_3 in relation to axes x, y, z (Eq. 1). Geometrically, it outlines a domain and results from the loading. Therefore, its geometrical presentation may be used for comparison of various loading patterns. Quantities like volume, surface area, cross-section area, or circumference of the cross section are the obvious options. This study presents basic cases of uniaxial, biaxial, triaxial tension and pure shear for an isotropic solid body. The first part describes analysis of the stress cases, while the other involves analysis of strain cases. Particular cases of pure shear and uniaxial tension proved to be most interesting. It is worth mentioning that in case of stress analysis this approach does not involve any material features, whereas for strain, Poisson's ratio contributes this material property into consideration. For the first time this approach was presented by the author in 2022 [1]. In Figure 1 there is an example of the stress domain for uni-axial tension, placed in a sphere of the points for the tri-axial tension. Next to it, its isometric view of half the domain with some geometrical quantities calculated is shown. The basic equation for normal stress is presented below (Eq.1) with principal stresses utilised.

$$\sigma_\mu = \sigma_1 \cos^2(\alpha_1) + \sigma_2 \cos^2(\alpha_2) + \sigma_3 \cos^2(\alpha_3) \tag{1}$$

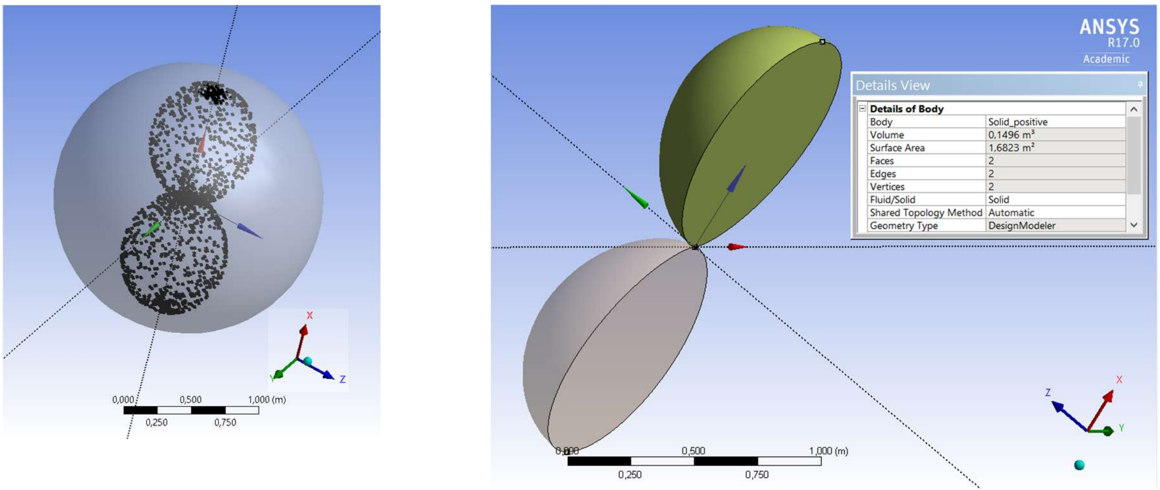

Figure 1. Clouds of points referring to normal stress tensor for uniaxial tension inside a sphere of triaxial tension [1].

The discussed approach has proved to be feasible in typical comparisons between pure shear and uniaxial tension, and biaxial tension as well. One of the discussed geometrical quantity namely, the circumference of the cross sections of the domains fits well with the Huber-Misses criterion for material's failure.

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[1] K. Wacławiak, *EngTrans.* **70**(2), 183-199, 2022. https://doi.org/10.24423/EngTrans.1311.20220602