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NOTCH DESIGNS WITH LOW STRESS CONCENTRATION

*** Pauli Pedersen**[1] **and Niels L. Pedersen**[2]

[1] Department of Mechanical Engineering,
Solid Mechanics
Technical University of Denmark
Nils Koppels Allé, Building 404,
DK-2800 Kgs.Lyngby, Denmark
email: pauli@mek.dtu.dk

[2] Department of Mechanical Engineering,
Solid Mechanics
Technical University of Denmark
Nils Koppels Allé, Building 404,
DK-2800 Kgs.Lyngby, Denmark
email: nlp@mek.dtu.dk

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ABSTRACT

For machine elements that must be designed also with respect to fatigue, the stress concentration factor for notches and grooves is an important quantity. Traditional designs with circular shapes are not advantageous and we show that stress concentration factors can be much reduced without the need for complicated shapes. To keep the shape simple we modify the circular shapes into elliptic shapes with only one parameter, the ratio of the ellipse half-axes.

The available results on stress concentration factors mainly relate to circular shapes in notches, grooves and fillets. Due to the circular shapes the curvatures are kept constant and this has the consequence that the stress concentrations are localized. The subject of stress concentration factors is extensive, but for the present study we restrict to single, symmetric notches in 2D models and to single, symmetric grooves in axisymmetric models. Fillets and holes/cavities are studied in a similar manner, see references [1] and [2].

The applied finite element (FE) modeling, the approach of parametric study with changed boundaries, and theoretical aspects of shape optimization are discussed. Available results in the book by Pilkey [3] are with good accuracy compared to a detailed FE analysis, before improved designs are determined. The limitation to elliptic designs is not severe since almost constant maximum stress are found along most of the new boundary. The improvement in stress concentration factor is drastic, typically from 2.8 to 2.2 or from 2.0 to 1.6.

The present study shows that important design improvements for notches and grooves are possible without loosing practical simplicity, and the descriptions of the improved notches and grooves are presented analytical. Two specific results are presented below.

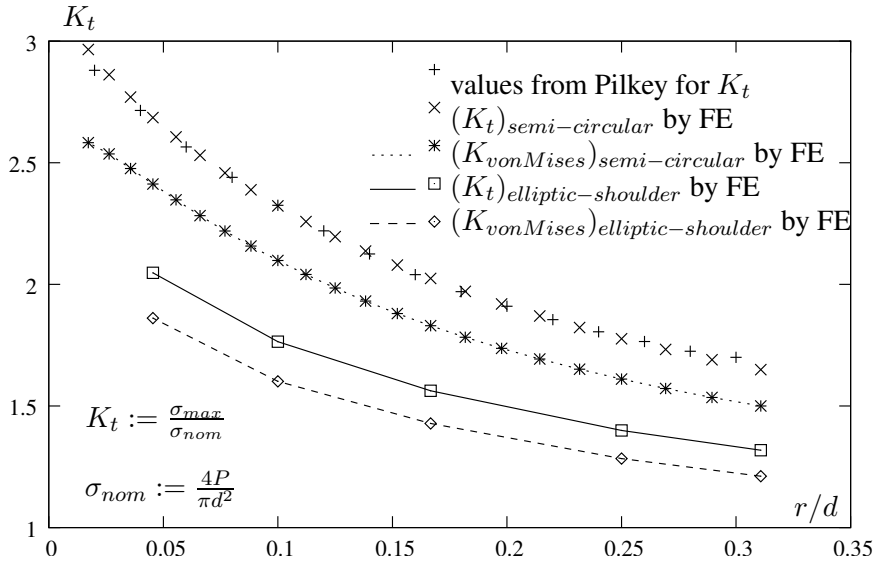

Figure 1: Stress concentration factors as a function of the relative size r/d for an axisymmetric groove in tension, presented for semi-circular designs and for elliptic designs with shoulder.

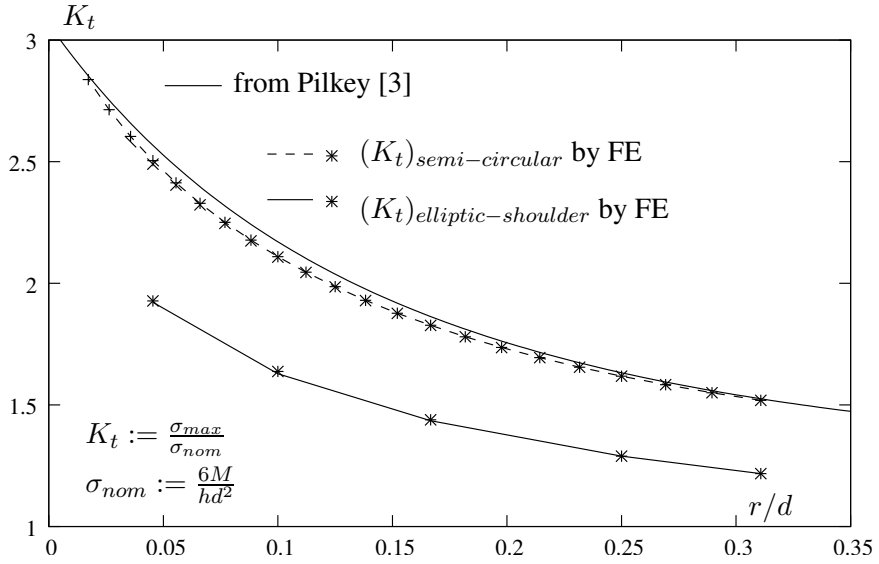

Figure 2: Stress concentration factors as a function of relative notch size r/d for semi-circular design and for the improved shape, elliptic design with shoulder, all assumed a 2D plane stress model in pure bending. From Pilkey [3]: $K_t = 3.065 - 6.637\frac{2t}{H} + 8.229(\frac{2t}{H})^2 - 3.636(\frac{2t}{H})^3$.

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