Jesmond ENGINEERING

Stress Concentration factors at Reinforced Holes

Task Objectives

It is well known that stress concentration factors around holes in flat plates can be reduced through the addition of a reinforcement typically consisting of an integral boss or stiffening ring. The determination of weight-optimised reinforcement dimensions has practical applications for the aerospace industry.

The Finite Element Method was used to model a large number of geometries to investigate how the stress concentration factor varies with the thickness and diameter of reinforcement for geometries loaded in uniaxial tension.

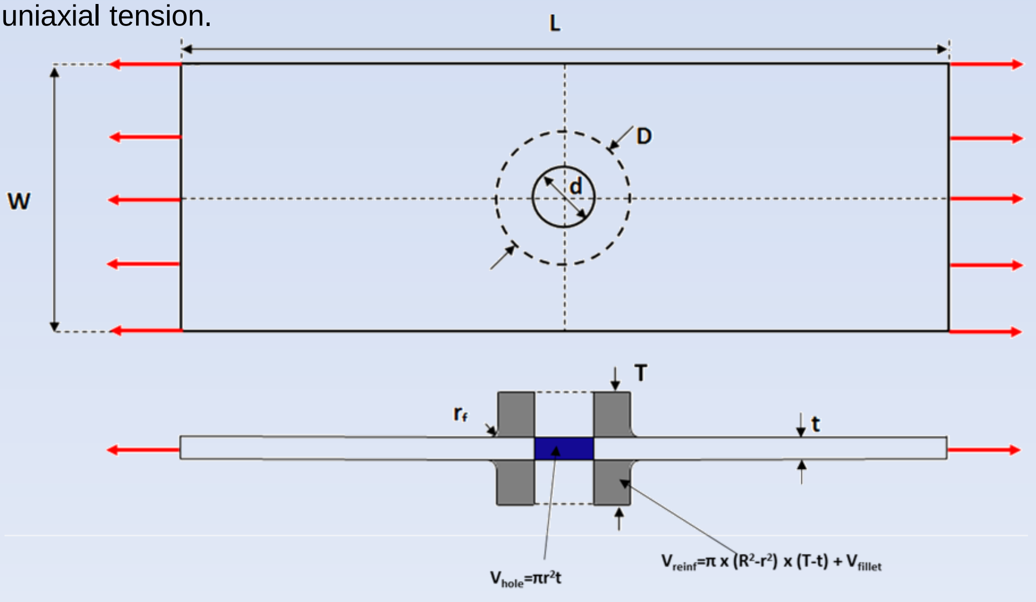

Figure 1 *Diagram of Integral Hole Reinforcement*

Finite Element Analysis Details

Due to the geometry having 3 planes of symmetry, only one eighth of the overall geometry was modelled with symmetry constraints applied, this significantly reduced the computational effort. The software package MSC/Patran 2012 was used for pre and post processing along with the solver MSC/Nastran 2012, utilising the linear static solution sequence SOL101.

The model was meshed using solid HEX20 elements with an Elastic modulus of 72400MPa and Poisson ratio of 0.33 assigned to represent the typical aerospace material 2014-T6 aluminium alloy.

The initial observations of results showed 2 distinct regions of high stress, at the hole bore and at the fillet radius between plate and reinforcement, a typical stress distribution is shown in Figure 2

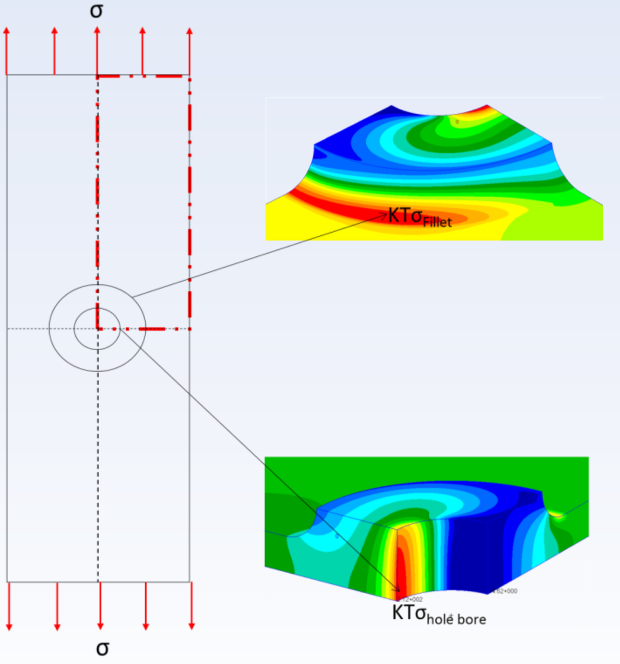

Figure 2 *Illustrative Plots Showing Regions of High Stress*

Continued overleaf

Results and Observations

Figure 3 shows K_{TG} factors for a range of geometries with the notable conclusion that the maximum stress at the fillet radius can exceed the stress at the hole bore, this tends to occur in geometries with combinations of high T/t, high D/d and low r_f/t and can generally be avoided by using as large a fillet radius as possible

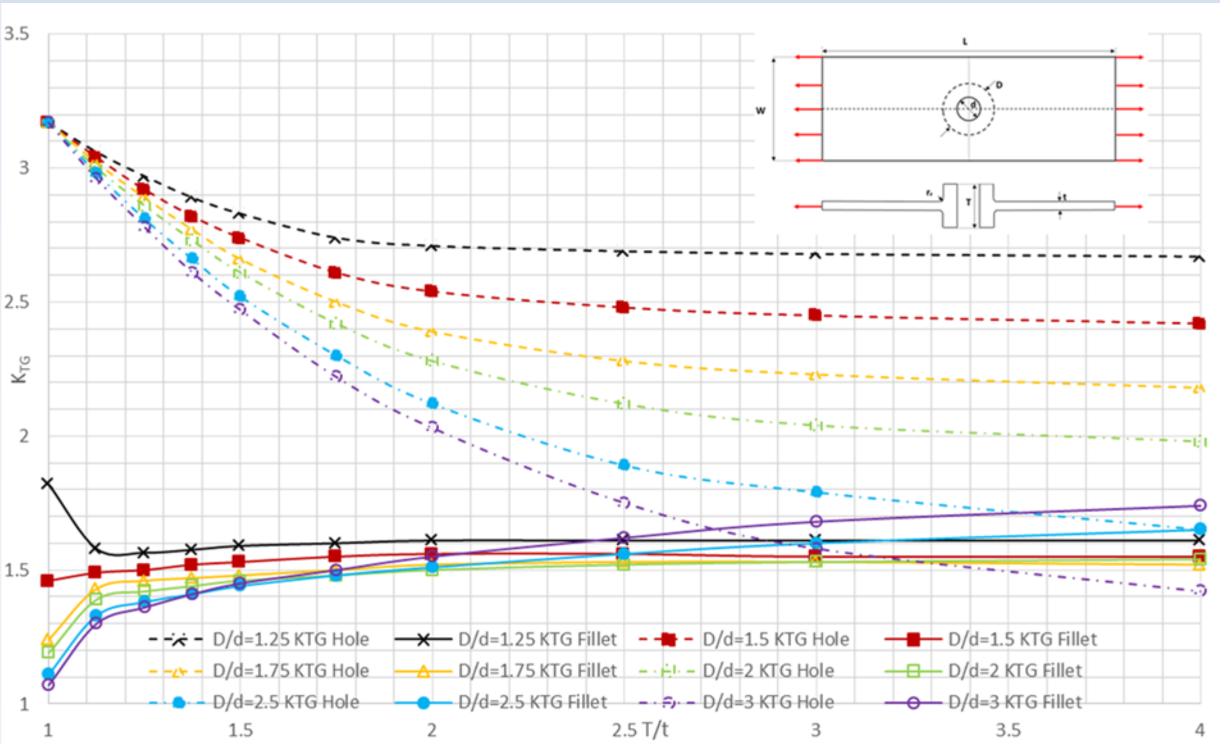

***Figure 3 -** FE analysis results for a range of geometries r_f/t=0.5*

For the optimum weight studies the thickness and diameter of the reinforcement were varied in increments while the overall volume of the reinforcement remained constant, Figure 4 shows the resulting curves which show a clear minimum K_{TG} for each constant volume in terms of both D/d and T/t, the level of reinforcement is in multiples of the hole volume (Vh). The curves can be utilised in industry to determine the minimum weight required to achieve a desired K_{TG}.

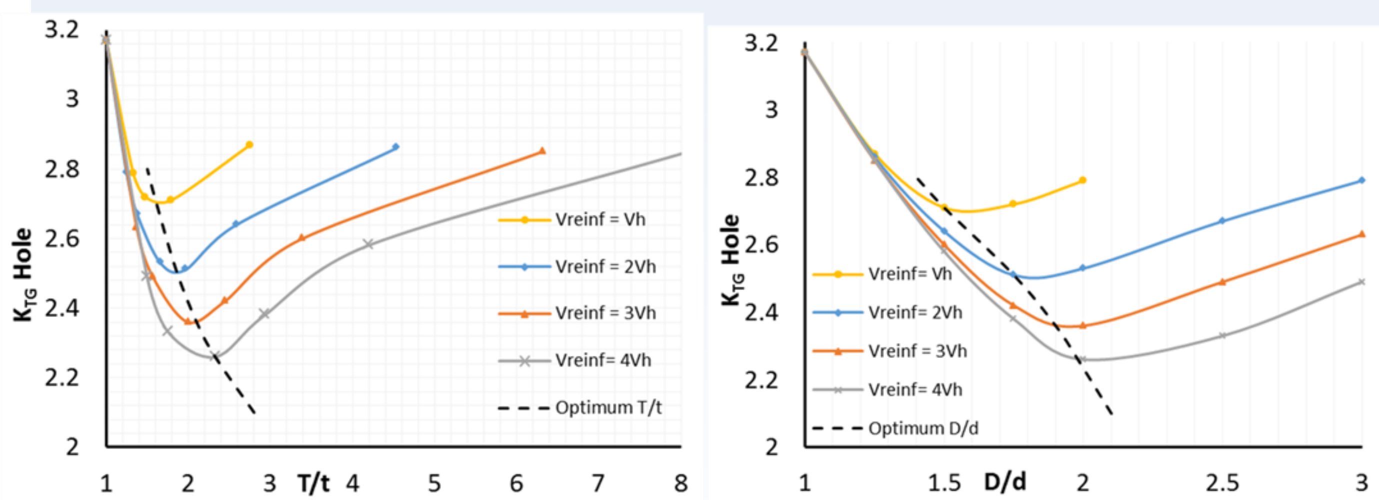

***Figure 4 –** K_{TG} results at the hole bore for constant volume reinforcement*

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