In the present investigation values of SIF have been evaluated in an aluminium alloy 2024-T_3 (Al–4·5% Cu, 1·5% Mg, 0·6% Mn) sheet by the finite element method with the help of a VAX 11/780 Computer. The results compare favourably with those predicted by an ASTM formula. Plastic zone shape and size at the crack tip have also been determined as functions of increasing nominal stress.

2. Stress field near the crack tip and the stress intensity factor

The investigation of the distribution of stresses in the presence of cracks in the body of a structure is essential because, under the influence of these stresses, these cracks may grow and at a certain critical value may lead to catastrophic failure.

Irwin (1957) used a method developed by Westergaard (1939) to formulate the stress fields in the vicinity of crack tips subjected to three modes of deformation namely, mode I (opening mode), mode II (forward shear mode) and mode III (parallel shear mode). Out of these three modes the details of mode I are given below and the stress components in the crack-tip stress field are shown in figure 1, as mode I describes the most severe loading condition.

$$\left.\begin{aligned}
\sigma_x &= \frac{K_1}{(2\pi r)^{\frac{1}{2}}}\cos\frac{\theta}{2}\left[1-\sin\frac{\theta}{2}\cdot\sin\frac{3\theta}{2}\right]\\
\sigma_y &= \frac{K_1}{(2\pi r)^{\frac{1}{2}}}\cos\frac{\theta}{2}\left[1+\sin\frac{\theta}{2}\cdot\sin\frac{3\theta}{2}\right]\\
\tau_{xy} &= \frac{K_1}{(2\pi r)^{\frac{1}{2}}}\left[\sin\frac{\theta}{2}\cos\frac{\theta}{2}\cos\frac{3\theta}{2}\right]\\
\sigma_z &= 0, \quad \text{in plane stress}\\
\sigma_z &= \nu(\sigma_x+\sigma_y), \quad \text{in plane strain.}\\
\tau_{xz} &= \tau_{yz} = 0\\
u &= \frac{K_1}{G}\left(\frac{r}{2\pi}\right)^{\frac{1}{2}}\cos\frac{\theta}{2}\left[1-2\nu+\sin^2\frac{\theta}{2}\right]\\
v &= \frac{K_1}{G}\left(\frac{r}{2\pi}\right)^{\frac{1}{2}}\sin\frac{\theta}{2}\left[2-2\nu-\cos^2\frac{\theta}{2}\right]\\
w &= 0, \quad \text{in plane strain,}\\
\varepsilon_z &= \frac{\nu}{E}(\sigma_x+\sigma_y) \quad \text{in plane stress,}
\end{aligned}\right\} \tag{1}$$

where σ_x, σ_y, τ_{xy} are stress components, r and θ are the coordinates, u, v and w are the displacements in the x, y and z directions, respectively, ν is poisson's ratio, G is the shear modulus and K_1 is the stress intensity factor (SIF). The critical value of SIF signifies the fracture toughness of the material. Therefore the evaluation of the SIF is very important.

In (1) in order to give the proper dimension to the stresses, K_1 must also be proportional to the square root of a length. For an infinite plate the only characteristic