CHAPTER VI

DISCUSSION OF RESULTS

The width and thickness of a test specimen are measured by a vernier length gage and their average values are used in the calculation. For a slit, its end radius of curvature is considered to be equal to the half of a drill's diameter whereas its required width is obtained by polishing side's surfaces and a dimension is checked by inserting a feeler gage into the slit.

During the experiment, a compensator is not employed, so the fringe order is observed to be an integral or half integral order only. In this work, the maximum fringe order of 4.5 is allowed to appear on the edge of a slit while a load is gradually applied. Because a bright field is used, the fringe order of 4.5 or any half integral orders has to be a dark band. The order of 4.5 is selected to be a maximum fringe at the slit's edge because it is easy and reasonable to observe by naked eyes or by looking through a telescope and this fringe value occurs when the load is increased to a medium value.

The experimental stress concentration factors of parallel-side slits are plotted in Fig. 5-1 and Fig. 5-2. It is seen that, in Fig. 5-1, the trend of curve of stress concentration factor versus the ratio of c/r increases with c/r. This occurs because the slit is made more slender at high c/r than at low c/r. The increasing rate of stress concentration factor with respect to c/r decreases slowly as the ratio of c/r increases. If the curve is extended for a small value of c/r, as shown by a dotted line in Fig. 5-1, the c/r approaches zero, which the slit becomes a circular hole with radius r, and it is clear that the stress concentration factor of a circular hole[1] in a uniformly stressed plate is equal to 3.

The curves of Fig. 5-2 represent the variations of stress concentration factor with slit's inclination. The curve are plotted at constant c/r and they are seen that as c/r increases the variation of stress concentration factor increases rapidly. At a particular c/r, the stress concentration factor is rather low when a slit has a small inclination, i.e., β is low and the stress concentration factor increases as inclination angle increases but the increasing rates of stress concentration factor with respect to β at different inclinations are not the same. That is, see Fig. 5-2, the increasing rate is low at a large angle of inclination and rather low at a low angle of inclination whereas it is very high when the angle of inclination around 45 degress. Therefore, the variation of stress concentrat[illegible] factor may be approximately considered to be a part of shifted cosine or sine function of β .

Fig. 5-3 shows the comparison of stress concentration factors of parallel - side slits which have different dimensions but the same ratio of c/r and the comparison also includes the stress concentration factor of a narrow slit. The curves are plotted at different slits' inclinations whereas c/r is kept constant at 16. To reveal the appearant difference in stress concentration factor, an axis of the graph is lengthened, see Fig. 5-3, to form a large scale. The curves show that the difference in stress concentration factor between a large dimension slit (c = 12.0 mm, r = 0.75 mm, c/r = 16) and a small one (c = 8.0 mm, r = 0.5 mm, c/r = 16) increases as inclination of slit increases. For the parallel - side slit, type I, at a small inclination the stress concentration factors of the two slits are somewhat different but it is not significant whereas at a large inclination, say β equal to 90 degrees, the stress concentration factor of the large slit is higher than that of the small one. As shown by the curves, the difference is likely high but it is calculated that the stress concentration factor of the large slit is actually 5.5 percents higher than that of the small one. Thus, the difference in value is relatively low because the experiment departs from the assumption that the plate is infinite. The plate used in the experiment has a width of about 80 mm, hence when the slit is made larger the ratio of a plate's width to the slit's length decreases. This makes the stress concentration factor of the large slit increases slightly.[2] For the narrow slit having the same focal length and the same end radius of curvature as those of the parallel - side slit, a trend of stress concentration factor curve deviates very little from the curve of the parallel - side slit. The difference in stress concentration factor is within 1 percent.

In Fig. 5-4 the stress concentration factor at the end of an elliptic hole is plotted according to eq. (32) and compared to the experimental result of a parallel - side slit. Consider the experimental curve and the curve of eq. (32) for a specified c/r, the curves show that the stress concentration factor of an elliptic hole decreases more quickly than that of the parallel - side slit while the angle of inclination decreases, but the trends of both curves are considered to be similar. At β equal to 90 degrees, the experimental values are close to those value which are calculated by eq. (32). The difference in stress concentration factor, at β equal to 90 degrees, increases with c/r, that is, and at c/r equal to 24 the maximum difference is calculated that the experimental value is 6 percents higher than the value calculated by eq. (32). The reason why the difference occurs is that in theoretical derivation of eq. (32) an infinite plate is concerned but in the experiment a plate of finite dimension is employed, and the widths of the two holes are not equal, i.e., the width of a parallel - side slit equals to 2r whereas the minor axis of the elliptic hole can be given by $2\sqrt{a^2 - c^2}$ or $2\sqrt{2c^2 + 2cr + r^2}$. This dimension will make the stress concentration factors of the two holes different. It is known that in the case of an elliptic hole, the maximum stress intensity does not occur at the end of the hole when an inclination angle is smaller than 90 degrees.[12] However, because the shapes of both curves are similar, the eq. (32) can be modified and compared to the experimental curves of a parallel - side slit with some accepted error.

Fig. 5-5 shows the comparison of stress concentration factors where the slit's inclination is 90 degrees. The curve presented by Cox[2] gives a higher stress concentration factor than the experimental curve for all values of c/r. At c/r equal to 12 the former gives the value of stress concentration factor 32 percents higher than that of the latter, but it must be noticed that the curve of Cox is obtained by a simple tension loading while the load in this study is uniformly distributed. Compare the curve of a rectangular hole with rounded corners where a′ equal to r, which the hole becomes a parallel - side slit, to the experimental curve. It is found that at c/r around 8 and 12 the stress concentration factor of the rectangular hole deviates very much from and is approximately 20 percents higher than that of the experiment. From the theoretical point of view, the curve of the rectangular hole is derived from Mises - Henceky criteria which is based on the strain energy of distortion[7][8], so the stress concentration factor depends on a value of Poisson's ratio and the curve shown in Fig. 5-5 for Poisson's ratio equal to 1/3 whereas the experimental curve of stress concentration factor is independent of Poisson's ratio. However, the experimental value of stress concentration factor almost satisfies the curve of an elliptic hole, the difference at c/r equal to 24 is only 6 percents. That is eq. (32) for an elliptic hole can be employed at an inclination angle equal to 90 degrees for a parallel - side slit of equal c/r.

In the last figure, Fig. 5-6, the comparison of stress concentration factors between experimental results of a parallel-side slit and the modification which is based on the equation of stress concentration factor at the end of an elliptic hole. The modification is made by using the experimental results as a guide line. From the curves in Fig. 5-6, if eq. (42) is used for a parallel - side slit when an inclination angle varies between 30 degrees and 90 degrees, and c/r varies from 8 to 24, an error always occurs when an inclination angle approaches zero, and when c/r increases. At c/r equal to 24 and the inclination angle equal to 30 degrees, the experimental stress concentration factor is 10 percents higher than the value calculated by eq. (42). Therefore, for the specified range, $30^\circ \leq \beta \leq 90^\circ$ and $8 \leq c/r \leq 24$, the stress concentration factor of a parallel - side slit calculated by eq. (42) is acceptable with an error less than 10 percents.

During the experiment, it is observed that the point of maximum stress intensity occurs at a point of tangency, as shown in Fig. 5-7, on both circular ends of the slit. Thus, if an inclination angles equal to 90 degrees, the point of maximum stress intensity occurs axactly at the ends of the slit[3] and this point departs from the slit's ends as the inclination angle decreases. However, this is not really significant if the slit is made long enough.