DISCUSSION

R. M. Wetzel[1] (*written discussion*)—We have learned a great deal from Dr. Crews and his colleagues at the NASA Langley Research Center. With this in mind I should like to ask him to comment on the following.

Notches are frequently less severe in fatigue than indicated by K_T, the theoretical elastic stress concentration factor. For this reason K_f, a "fatigue strength reduction factor" or "fatigue concentration constant," is frequently defined for a given notched specimen as [*1*][2]

$$K_f = \frac{\text{fatigue strength, unnotched specimen at a given life}}{\text{fatigue strength, notched specimen at the same life}} \qquad (1)$$

K_f factors so defined are constant at long lives but tend to decrease toward 1.0 at shorter lives because of inelastic deformation. Several authors (for example, Refs *2–4*) have derived empirical expressions for determining the value of K_f at long lives; however, it has been my experience that these expressions are unreliable particularly when applied to specimens of a different material or geometry than originally used to derive the relationships. Therefore, whenever possible, I think it advisable to determine, or at least verify, K_f values using Eq 1 and experimental data for the specimen in question.

With this introduction I should like to question Dr. Crews' statement that K_f was nearly equal to K_T for the specimens he used. The unnotched specimens used to simulate the fatigue behavior of notched plates lasted 0.4 as long as the notched plates. This was explained as being the result, in part, of a size effect, since a larger volume of metal was highly stressed in the unnotched specimens than in the notched specimens. The observation, as well as Dr. Crews' explanation, supports the alternate view that K_f as defined by Eq 1 would be significantly less than K_T. Use of this K_f in place of K_T in Neuber's equation (Eqs 1 and 2) would improve the agreement between the unnotched specimen lives and the notched specimen lives.

In general, I believe that the "fatigue concentration constant," K_f, determined from long-life data and Eq 1, should be substituted for K_T when Neuber's equation is applied to fatigue problems. This conclusion is verified in Refs *5–8*.

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[2] Italic numbers in brackets refer to the list of references at the end of the Discussion.

It is gratifying that Dr. Crews' results agree with a similar investigation which also studied the effect of prior plasticity and utilized Neuber's equation and the technique of simulating notch behavior with unnotched specimens. This work was done at the University of Illinois. It is reported in detail in Ref *8* and is summarized in Refs *6* and *7*.

J. H. Crews, Jr. (author's closure)—The size effect present in the fatigue behavior of notched specimens can be interpreted as the combined result of two effects, both related to the size of the highly stressed region at the notch. In small notched specimens or in specimens with high K_T values, the highly stressed region may be small compared to the microstructure of the material. For such cases, the local stress gradient may be attenuated by material inhomogeneity, and, as a result, local stress may be less than predicted by K_T. The second factor that produces a size effect is related to the initial size of the critical flaw that eventually develops into a fatigue crack. As previously discussed in this paper, the critical flaw at the notch is smaller than its counterpart in the unnotched specimen. As a result of this difference in initial flaw size, a notch may be less severe than predicted from the fatigue behavior of unnotched specimens.

In large specimens with mild stress concentrations, as in the present study, elastic local stresses are in agreement with K_T. Observed long-life size effects for such cases are usually small (K_f nearly equal to K_T) and are attributed to the initial flaw size effect.

In the present study measured elastic local stresses (strains) were in agreement with K_T, as expected. Therefore, K_T was used in Neuber's equation for the calculation of local cyclic stresses. The substitution of K_f for K_T in Neuber's equation, as suggested by Dr. Wetzel, would have decreased these calculated local stresses and would have increased the life estimates. However, since the size effect was attributed to the initial flaw size effect, it would have been inappropriate to correct for this effect by deliberately altering the calculated local stresses.

In my view, since the notched specimens in the present study were large, K_T was appropriately used in Neuber's equation. The question of using K_T or K_f for smaller specimens was beyond the scope of this study.

References

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