DISCUSSION

D. R. Miller[4]

The writer and his colleague Mr. T. D. Younkins would have appreciated an acknowledgment by the author of our prior work on this problem. In July, 1958, the writer did the original work on the problem treated by the author, and showed that small changes in an axial gap of the can-supporting structure of a canned rotor could cause plastic strains in the can. This work was described to the author and his associates on several occasions thereafter.

On September 21, 1960, a memorandum which presented an extension of the writer's work was issued by Mr. Younkins. The memorandum presented a theoretical analysis of the cyclic elastic and plastic strains in test specimens in the author's orginal fatigue test apparatus. The analysis was described on November 30, 1960, at a meeting attended by the author.

The author's presentation is not clear in some respects, and he has been inaccurate in some areas. He has analyzed the stress and strain distribution which results from increasing the can-support gap by an amount δ. He has not explained what stress and strain distribution results from returning the gap to its original dimension. For variations of gap which produce strains which are several times the nominal elastic limit, and after several cycles of gap variation, the stresses and strains would be essentially the same at the two extremes of gap variation, except for a reversal of algebraic sign. The complete cycle must be analyzed to determine the maximum strain range in the can, and the effects of work hardening of the can material should be taken into account by using the cyclic stress amplitude-strain amplitude characteristic rather than that which corresponds to monotonic loading. It should also be recognized that the cycling of pressure in combination with thermally induced changes in the gap can cause local progressive thinning or thickening of the can.

In the derivation of equation (6) the coefficient $(1 - \nu^2)$ should have been included in the last term, because an essentially plane-strain condition exists in the can over the gap as well as elsewhere. In equation (7) the author has used relations applicable to a uniaxial-stress condition rather than the triaxial-stress plane-strain condition which actually exists.

There are inconsistencies in the value of $\epsilon_y = 0.003$ (approx.) in Fig. 3 and in the value $\epsilon_y = 0.002$ in Table 3 with the expression $\epsilon_y = \sigma_y/E$ (equation (10)), since for Inconel the latter would give a value of about 0.001.

In Table 3, correction of an arithmetic error in the value of δ for the first case would give a better correspondence between the fatigue lives actually observed and those which would be predicted on the basis of the author's analysis.

In Table 4 the author shows the same lives based on Low for specified values of ϵ_p for materials having different yield strengths. This is not correct, because Low's plot shows the total strain amplitude rather than the plastic strain amplitude. It is not clear to the writer what strain values were referred to Fig. 8 to obtain data which are shown in Tables 3 and 4.

A more direct and accurate check on the theoretical analysis of the strains in the can would have been obtained if the author had measured the strains in the can. Strain measurements would have given an indication of variations in strains caused by work hardening or softening of can materials and changes in friction coefficient caused by cyclic slippage as well as showing how strain distributions change during initial shakedown in a particular test.

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Author's Closure

Since the discusser brought up the subject of acknowledgments, the author feels that some comments in this connection are in order.

The author's original acknowledgments contained a long list of names of people from various organizations who had been connected with the problem. The discusser's name was one of them. After the paper had passed through approximately a half dozen approval agencies required for publication of this type of paper, the acknowledgments had been rewritten almost as many times, and about the only wordings remaining from the original acknowledgments were the last two lines.

As far as some specific comments are concerned, the author does recall that at the meeting the discusser is referring to in July of 1958, the discusser vigorously insisted on a radial motion fatigue case while the author from his work to that date strongly promoted an axial motion fatigue. The severity of the radial motion fatigue was later proven by the author and his co-workers to be of minor importance.

If the analysis the discusser is referring to agreed with the test results from "the author's original fatigue test apparatus," it must necessarily have been incorrect, because that test apparatus gave erroneous test results. For example, at 0.007 in. axial motion failure was recorded at 60,000 cycles, while the correct result, as reported in this paper and obtained from justifiable test results, is 500 cycles.

Concerning the technical aspects of the discussion, it is pointed out that the strain-hardening effect would raise the yield stress slightly. However, a slight change in the yield stress would have only a slight-to-negligible effect on the *short* endurance fatigue aspects. This is already pointed out in the paper. Inclusion of $(1 - \nu^2)$ over the gap as well as small variations in ϵ_y also would have but a negligible effect on the *short* endurance fatigue life.

Table 4 shows a summary of the results as obtained using the procedure in Table 3, where it is shown in detail that the total strain is used in the "Present Tests" as well as in "Low's Tests." It should be noted that both the yield stress and the plastic strains are given in Table 4.

In the very early stages of the investigation, strain measurements were made on one of the thin-walled shell tests. No information was obtained from this test that would alter anything given in the paper.