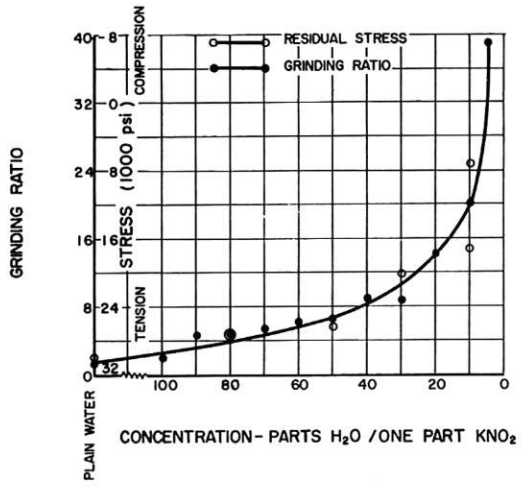

Fig. 5 Grinding ratios and residual stresses for 6Al 4V titanium alloy for "low-speed" grinding with various concentrations of grinding fluid

Conclusions

Based upon the tests conducted, it is concluded that endurance limit of residually stressed titanium differs from the endurance limit of unstressed titanium by 1/10 of the value of the corresponding residual stress. Compressive stress causes increase, and tensile stress causes decrease from par-bar value.

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DISCUSSION

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The authors have clearly shown that tensile grinding stresses of considerable magnitude have only a rather small adverse effect on the fatigue limit of a titanium alloy, just as the writer and his associates showed this to be true for hardened steel (Reference [5]).

The principal difference between the fatigue results for titanium and for steel is that the latter could not be represented by a single curve passing through both the compressive and tensile stress ranges, as was done in Fig. 2 for titanium. It is quite possible that this difference is related to a difference between the ways in which the residual stress curves for the two materials vary with depth below the surface.

For titanium, the magnitude of the residual stress decreases continuously from its maximum value in the layer at the surface, while for steel the residual stress may start out as either compressive or tensile at the surface and then pass through a tensile peak just below it. When the residual stress curve is this complex, either the peak tensile stress or the surface stress may be more important with respect to the fatigue limit, depending on the magnitude involved.

It turned out that the fatigue limits for steel could not be plotted in any significant way as a function of the residual stress at the surface, but only as a function of the subsurface peak tensile stress. Most of the points fell on a horizontal curve which curved downward a little when the tensile stress was fairly high, but some others, for which the surface stress was highly compressive, fell above this curve. A very similar curve can be drawn through the points of Fig. 2 if those corresponding to residual compressive stress are excluded from consideration.

Thus the effect of residual stress on the fatigue limit is the same for both titanium and steel when the stress is predominantly tensile. Likewise, compressive stress is beneficial for both metals from the standpoint of fatigue, even though the complexity of the residual stress pattern for steel makes it impossible to show this by means of a simple curve like that of Fig. 2.

In order to have some idea of the accuracy with which the fatigue limits were determined, it would be well to state the load increment used in the staircase method.

Authors' Closure

We wish to thank Dr. Tarasov for his remarks on the relationship of surface residual stresses to fatigue life for both titanium and steel. As pointed out, our titanium paper and the hardened steel paper (Reference [5]) by Dr. Tarasov and his associates have many points in common. However, the main difference probably is that we tried to minimize all variables except surface stress and endurance limit, while Dr. Tarasov and his associates evaluated using a complex stress pattern. We hope that this complex picture will be studied further.

In regard to the question on load increments for the staircase fatigue tests, we used 2500 psi increments.

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