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N90-25062

FLEXURAL FATIGUE LIFE PREDICTION OF CLOSED HAT-SECTION USING MATERIALLY NONLINEAR AXIAL FATIGUE CHARACTERISTICS

by

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Straight or curved hat-section members are often used as structural stiffeners in aircraft. For instance, they are employed as stiffeners for the dorsal skin as well as in the aerial refueling adjacent area structure in F106 planes. The flanges of the hat-section are connected to the aircraft skin. Thus, the portion of the skin "closing" the hat-section interacts with the section itself when resisting the stresses due to service loads. The present investigation is circled around an estimation of the flexural fatigue life of such a closed section using materially nonlinear axial fatigue characteristics.

It should be recognized that when a structural shape is subjected to bending, the fatigue life at the neutral axis is infinity since the normal stresses are zero at that location. Implicit in this statement is the assumption that the fatigue failure will not occur due to shear stresses. Conversely, the fatigue life at the extreme fibers where the normal bending stresses are maximum can be expected to be finite. Thus, different fatigue life estimates can be visualized at various distances from the neutral axis. The problem becomes compounded further when significant portions away from the neutral axis are stressed into the plastic range. Furthermore, the fatigue life of a structure is highly material-dependent. Whereas a typical structural component of an aircraft is subjected to a complex state of fluctuating stress, the fatigue characteristics of materials are generally available on miniature specimens under direct tension and compression stresses. The problem posed herein, therefore, can be approximately stated as follows. How can the fatigue life of a closed hat-section be predicted when it is subjected to a cyclic bending moment when the fatigue characteristics of its material are known only under direct axial loading conditions for miniature specimens?

A theoretical analysis of the closed hat-section subjected to flexural cyclic loading is first conducted. The axial fatigue characteristics together with the related axial fatigue life formula and its inverted form given by Manson and Muralidharan are adopted for an aluminum alloy used in aircraft construction. A closed-form expression for predicting the flexural fatigue life is then derived for the closed hat-section including materially nonlinear action. A computer program is written to conduct a study of the variables such as the thicknesses of the hat-section and the skin, and the type of alloy used. The program is first checked by zeroing-in on the S-N curves for a simple solid rectangular section published by Manson and Muralidharan. The program is then used to develop the fatigue life prediction curves for the closed hat-section under investigation. The study has provided a fundamental understanding of the flexural fatigue life characteristics of a practical structural component used in aircraft when materially nonlinear action is present.