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# STRESS LIFE CURVES FOR THE GIGACYCLE FATIGUE REGIME

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Fatigue failure is a common phenomenon in metallic structural elements when subjected to cyclic loading. According to recent studies, there is no fatigue limit for metallic materials. It has been verified that the stress life (S-N) curve continuously drops even after $10^7$ cycles; this very high cycle fatigue regime is called the gigacycle fatigue regime. However, S-N curves provided in most of the design codes and literature assume that there is a fatigue limit. It is important to modify these S-N curves when they are used in designing.

Developing S-N curves up to the high cycle fatigue regime is commonly done by using simple experiments such as the rotating bending test. However, experiments in the gigacycle regime require sophisticated equipment, much energy and time. Therefore, a need arises for a model (the first objective of this study) for predicting S-N curves in the gigacycle regime using available S-N data at high cycles.

Experimental studies show that, in the gigacycle regime, fatigue cracks initiate from non metallic inclusions (or defects) which exist in metals or form during the production process. First, the threshold crack called the optically dark area forms inside metallic materials and subsequently the pure fatigue crack growth starts. Widely used fatigue strength prediction models for the gigacycle regime have been developed based on the Murakami model where the *size of the optically dark area* and *Vickers hardness* are used as governing factors. Even though *Vickers hardness* is easily tested, determining the *size of the optically dark area* is complex. Therefore, the slope prediction model should be independent from the *size of the optically dark area* (the second objective of this study).

In order to achieve the objectives, a simplified model developed by us for predicting the fatigue strength of steel in the gigacycle regime for stress ratio R=-1 based on the Murakami model and Wang *et al*'s modifications, is used. In this model, the *size of the optically dark area* is replaced by using a function of the *ultimate tensile strength* of steel. Accordingly, the distinctive features of the proposed model are that the model is independent from the *size of the optically dark area* and that it only consists of *ultimate tensile strength* and *Vickers hardness*.

The proposed model is then verified by using experimental S-N data for four medium strength steels (i.e. wrought iron, FCD400 iron, D38MSVS5 steel and S55C steel).

The proposed model will be a versatile tool for designing and fatigue life evaluation of steel structures. Further, it could also be used in mechanical component designs where the effect of the gigacycle regime is a known fact.

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