Fatigue design of welded joints treated by high frequency hammer peening

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In comparison with the base and filler materials used, welded structures have relatively low fatigue strength. This is mainly due to the initiation stage which become very weak in the specific case of welded assemblies. Early initiation of fatigue cracks can be explained by the presence of residual tensile stresses, high stress raisers and an often poor surface roughness at the weld toe. It is therefore essential to have a design that takes into account the specific features in the case of exposure to cyclic loading. In addition, it is possible to apply post treatments such as TIG dressing, grinding, shot peening or hammer peening. It is generally observed that the gain will be all the more significant since the stresses will be limited and ultimate tensile strength will be high.

High frequency hammer peening (HFH) is a recent improvement method which is probably one of the most effective for treating welded assemblies. However, there is a certain number of technical difficulties that must be overcome to apply HFH whether for new or old structures. Using the various results available for this process is uneasy for the fatigue design of an HFH treated welded assembly for a given configuration and treatment parameters. The work presented falls within the framework of a project which should in the long run propose an industrially applicable approach with the aim of increasing the guaranteed fatigue life of new structures and to extend the one of existing structures.

The numerical approach developed in this study can be decomposed in 4 main parts. Firstly, the local properties of the considered welded joint have to be assessed in order to model it. The use of instrumented indentation coupled to a reverse method permits to estimate the local tensile curves (through the weld zone, the HAZ and the base metal) with a good accuracy and quickly than the mainly other existing solutions. Then, the treated weld toe can be modeled in a second part via the finite element method. To decrease the time consuming of the classical step-by-step incremental method, a direct method can be used in some cases. In our study, we modified and used the pass-by-pass stationary method proposed by Dang Van and Maitournam. Once the treatment simulated, the third part aims to predict the possible stress relaxation during the fatigue loading. Once again, a direct method have been used based on a combination of the work of Zarka and the direct method of Akel and Nguyen. The last part of the proposed approach aims to predict the fatigue life of the welded assembly considering the numerical results obtained. This can be done through various ways. In our case we directly used the Manson-Coffin-Basquin relation modified by Morrow. The cyclic properties required are assumed to be similar to those of the base metal and have been estimated by low cycle fatigue tests. Equivalent results have been also obtained by using directly the Uniform Material Law as well as the medians method which both allow to assess the cyclic properties needed knowing the static ones.

Finally, a good agreement have been obtained between the numerical approach and the experimental study. In addition, the proposed numerical approach permits to better understand the effect of the main HFH parameters and makes it possible to consider developing software to estimate the fatigue life of a treated structure.

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