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UNDERSTANDING FATIGUE DAMAGE PROGRESSION IN A STRUCTURAL STAINLESS STEEL THROUGH CYCLIC BALL INDENTATION TESTING

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Abstract

Understanding fatigue damage progression and estimating remaining life of dynamically loaded components has been a major challenge for several safety critical in-service components. Quite often, a small scoop of material is extracted from an in-service component and using the small volume of material, the fatigue property is estimated. Towards this, a few small specimen fatigue test methods are available, such as, cyclic ball indentation, cyclic small punch test and cyclic bulge test etc.

Amongst the small specimen test methods used for miniature specimen testing, cyclic ball indentation [1] has the potential to be deployed in-situ during plant maintenance to record fatigue response of localized spots. The method uses a spherical indenter of 1/16” (~1.58 mm) diameter which applies cyclic compression-compression loading on the material at selected location and monitors the load-displacement response continuously to identify failure event due to fatigue. Acoustic emission technique has been used to complement the fatigue failure identification [2]. Thus one could use the cyclic ball indentation test method in association with acoustic emission to construct a failure life curve for in-service material, which experiences a complex history of mechanical, environmental (thermal, corrosive) loading. One aspect that has not been captured well so far is how to correlate the failure life from cyclic ball indentation with standard specimen test data.

To capture a complete picture of this, controlled experiments using carefully prepared dog bone fatigue specimens of SS 304 have been conducted in the author’s laboratory. Prior to start of the fatigue experiments, AE signatures have been obtained using pencil break test (PLB) as well as cyclic ball indentation at a location on gage length. The dog bone specimen is fatigue cycled under tension-tension uni-axial loading till failure, with AE signature capture during fatigue cycling. The load levels are selected to be above the endurance limit of the material, but below the yield strength. In addition, the fatigue cycling is interrupted periodically and cyclic ball indentation tests are carried out again at some locations of gage length to identify failure life cycle data of controlled damage fatigue cycled specimen through displacement sensing and hysteresis area. Data obtained from cyclic ball indentation is then correlated with loss of stiffness (or elastic modulus) of fatigue cycled specimen. It may be noted that the cyclic indentations are carried out at different locations of dog-bone specimen to avoid repeat indentation at same location. A part of the experimentation and data analysis is in progress; it is hoped that the work will be ready for presentation by June 2023.

Keywords: Fatigue damage progression, cyclic ball indentation, acoustic emission technique.

References:

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