A REVIEW ON EXPERIMENTAL ANALYSIS AND STUDY OF PREDICTION OF FATIGUE LIFE FOR SPOT WELDED JOINTS WITH DIFFERENT ARRANGEMENT

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ABSTRACT

Spot welding is mostly used method to join sheet metals for automotive components. A typical heavy or light commercial vehicle may have more than 2000 spot welds. In real structures, the use of multisport welded joints is more frequent as compared to single spot welded joints. Multi-spot welded joints are routinely used in the automotive and other industries to produce structurally critical components. Most researchers however have been focused to a single spot welded joints until now. It is found that the fatigue behavior of multi spot welded joints is different from that of single spot welded joints. Many engineering components such as automotive bodies and aircraft structures are subjected to complex states of stress Most researchers however have been focused to a single spot welded joints until now. It is found that the fatigue behavior of multi spot welded joints is different from that of single spot welded joints. This paper reviews the existing literature by different researchers regarding fatigue life of spot welded joints.

Keyword: - *Fatigue Life, Spot Welded Joint.*

1. INTRODUCTION

It is important for the automotive design engineers to understand the mechanical behaviors of different joints and furthermore, to incorporate the static, impact, and fatigue strength of these joints in the early design stage. The determination of capability of a particular material to survive the many cycles a component may experience during its lifetime is the aim of fatigue analysis. Fatigue Analysis has three main methods, Strain Life, Stress Life, and Fracture Mechanics There are three distinct regions of the fatigue process. Region I is associated with the growth of cracks at low stress intensity factor ranges and is commonly believed to account for a significant proportion of the fatigue life of a component. Region II is the stable crack growth region and has been extensively studied for its technological importance. Rapid crack growth occurs in region III and this region is typically thought to account for a small fraction of the total life. Although more and more joints are being used in vehicle assemblies, very limited performance data on joints have been reported in the open literature. Since spot welds in automotive components are subjected to complex service loading conditions, various specimens have been used to analysis fatigue lives of spot welds. Many engineering components such as automotive bodies and aircraft structures are subjected to complex states of stress. The complex stress states in which the two or three principal stresses are proportional or non-proportional often occur at geometric discontinuities, e.g., notches or joints connections. The fatigue phenomenon under these conditions, termed as multiaxial fatigue, is an important design consideration for a reliable operation and optimization of many engineering components. Therefore, the multiaxial fatigue analysis becomes an essential tool for approximating the fatigue lives of these components. Despite of existence of a large number of multiaxial fatigue criteria in the literature, engineers are often faced with some problems in the application of these criteria in the engineering design. The application of these criteria for complex multiaxial loadings is one of the most important problems. Unfortunately the size and complexity of the joints often limits the practicality of testing their mechanical properties, particularly when long term testing is required, such as in the case of determining fatigue properties. Conversely, single spot welded joints are easily produced and can be tested on existing equipment with little or no modification. Clearly it would be extremely advantageous to be able to predict the fatigue properties of a multi-spot welded component based on the data obtained from testing single spot welded joints.

2. LITTERATURE REVIEW

Bonnen et al. (2009) evaluated the performance of five fatigue damage parameters in the context of large fatigue data sets consisting of hundreds of tests. One parameter by Swellam57 is based on a fracture mechanics approach, while the other four by Rupp et al., 58 Sheppard,59 Dong60 and Kang61 are based on a structural stress approach. One of the evaluation methods used by Bonnen is to estimate the specimen life using the parameter and compare the estimate against the actual fatigue life observed in laboratory tests. All parameters resulted in a reasonab le fit to the experimental data for these specimen geometries, with the Swellam's parameter showing the most scatter among them.

McMahon et al. (2006) found that spot welded low carbon and high strength steel joints have shorter crack initiation cycles under variable amplitude (random) fatigue loading than under constant amplitude loading.

Lawrence et al. (2002) performed a series of fatigue tests on spot welded low-carbon and HSLA steel joints. They tried to improve the fatigue properties of spot welded joints by controlling the residual stress, weld geometry, increasing base metal strength and steel sheet surface condition. They observed that tensile shear spo t welded specimens show significant fatigue strength improvement by treatments which either reduce the tensile residual stress or induce compressed residual stress. The improvement through modification of weld geometry was smaller than that obtained by residual stress control.

Anastassiou et al. (1990) found that residual stress in the spot welded joint increases with the thermal cycle intensity, but expulsion and post-heating reduces residual stress. They also found that residual stress affects the fatigue strength of the joint in a high cycle fatigue regime of around 107 cycles (or at low fatigue load). The fatigue strength of a spot weld made above the expulsion limit exhibited a higher fatigue strength compared to those without expulsion. However, Anastassiou found that the post heating cycle does not improve fatigue strength because, even though the post-heating cycle decreases the residual stress level, it decreases the ultimate strength of the material at the same time. In addition, they found that the weld geometry (spot nugget edge n otch radius) has a more significant effect on fatigue strength than residual stress under high fatigue life (107 cycles), which is believed to be due to the high stress concentration in the circumferential notch in the joint produced by different welding conditions.

Spitsen et al. (2005) performed post-weld cold working (similar to coining) on a low carbon steel spot welded joint using a special shaped indenter after welding to produce benefi cial residual stresses. They found that cold working increases the fatigue strength of low carbon steel spot welded joint by about 67% under high cycle (4 × 106) fatigue, with no effect on the static tensile shear strength of the joint.

Chang et al. (2019) also investigated the effect of forging applied immediately after the welding cycle on the residual stress distribution in spot welded aluminum alloy sheets. Finite element analysis was used to determine the residual stress distribution with and without forging treatment. They suggested that forging significantly reduces the residual stress in the HAZ area but no noticeable reduction could be found in the spot nugget edge area. Fatigue tests were carried out and showed that fatigue strength of spot welded aluminum alloys improved and the crack always initiated in the nugget edge area, compared to initiation at both the nugget edge and HAZ area for the unforged welded specimens.

Bae et al. (2020) used a three-dimensional non-linear finite element model to simulate residual stress distribution in spot welded cold-rolled steel sheets. The simulated results were compared with stresses measu red using X-rays and good agreement was found. This three-dimensional (3D) specimen model was then used to conduct stress analysis of a tensile shear spot welded joint under fatigue loading. Once the stress distribution in the joint was determined, a fatigue strength assessment approach that considered the residual stress was also proposed. In this approach, Goodman's equation was modified by adding residual stress as shown in Equation [

Yang et al.(2001) used a three-dimensional thermal elastic–plastic finite element model (not a fully coupled electrical–thermal–metallurgical– mechanical model) to determine residual stress in a spot weld and to obtain the multiaxial stress state in the weld under applied fatigue load. Corresponding to this mutiaxial stress state, an equivalent uniaxial stress SN was obtained using Sine's method as shown in Equation.

Khanna et al.(2001) have determined the residual stress variation in steel spot welds using the moiré interferometric method and hole drilling by developing the optical equivalent of a three-element strain gauge rosette. The displacement field near the edge of the blind hole was measured in the x-, y- and 45°-directions using the corresponding moiré fringe patterns and the biaxial residual stress field was calculated. They measured residual stress state in several different spot weld configurations such as single face tensile shear, double face tensile shear and through tension specimens. The residual stress distributions measured using the optical method agree with other experimental and modeling studies.

3. CONCLUSION

Currently there are several models that propose methods for predicting the fatigue life of a given joint of simple geometry, the majority of which are based on a fracture mechanics approach. However, as more spot welds are added and the complexity of the joint increases, these existing models tend to lose their accuracy.

4. REFERENCES

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