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A REVIEW PAPER ON DEVELOPING AND ASSESSING THE LONGEVITY OF WELDED JOINTS WITH VARIED EDGE PROFILES THROUGH FINITE ELEMENT METHOD (FEM)

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ABSTRACT

This review paper delves into the exploration and evaluation of the lifespan of welded joints featuring diverse edge profiles, employing the Finite Element Method (FEM). The focus is on understanding the factors influencing fatigue performance, particularly in the context of stainless-steel bridge design and construction. Fillet-welded joints, commonly susceptible to fatigue damage in load-bearing components, are scrutinized. The analysis encompasses various edge profiles, such as concave shapes with different arc radii and chamfering with varying radii, considering their impact on fatigue life. Numerical simulations are employed to conduct a comprehensive assessment. The results reveal that a perpendicular side fillet profile with a 140 mm radius exhibits the maximum joint lifespan compared to other profiles. These findings provide crucial insights for bridge designers and engineers, facilitating the optimization of welded joint designs and overall enhancement of fatigue performance in stainless-steel bridges. The relevance of this study is underscored by recent advancements in stainless-steel bridge technology, making it a valuable resource for future research in this domain.

Keywords: Design, Welding, Joints, Fatigue, Lifespan and Edge.

1. INTRODUCTION

Welded joints play a pivotal role in diverse industrial applications, contributing significantly to the structural integrity of various components. The longevity and fatigue performance of these joints are critical considerations, especially in the context of evolving engineering practices and material preferences. This review paper explores the development and assessment of the lifespan of welded joints, with a specific focus on the influence of varied edge profiles. Utilizing the Finite Element Method (FEM), this study aims to provide a comprehensive understanding of the factors affecting the fatigue performance of welded joints. As materials and construction techniques continue to advance, stainless steel has emerged as a prominent choice in bridge design and construction. The increasing popularity of stainless steel necessitates a deeper understanding of the nuanced factors that impact the fatigue behaviours of welded joints. In this context, fillet-welded joints are of particular interest due to their common occurrence and susceptibility to fatigue damage in load-carrying components. The analysis in this review encompasses an examination of different edge profiles, including concave shapes with varying arc radii and chamfering with different radii. The positioning of these profiles relative to the sample profile is also considered. Through rigorous numerical simulations using the Finite Element Method, this study aims to unravel the intricate relationships between edge profiles and the fatigue life of welded joints. As shown in figure 1.

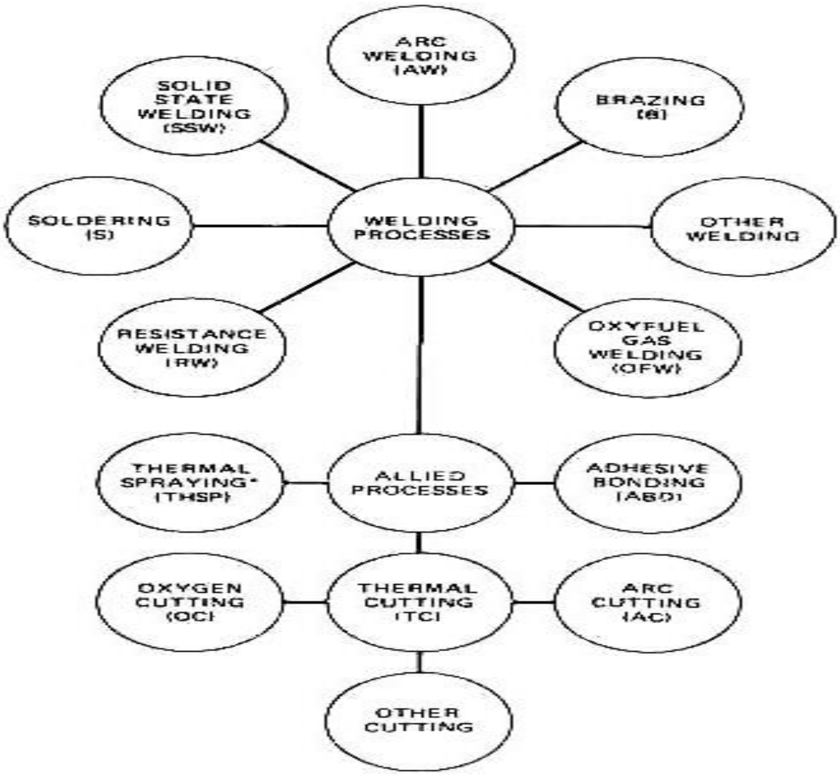

Figure 1 Welding Process

2. LITERATURE REVIEW

Literature reviews are integral components of academic research papers, theses, dissertations, and scholarly articles. They serve to situate the research within the existing body of knowledge, demonstrate the researcher's familiarity with prior work, and justify the need for new investigations.

S. Chauhan et.al. (2023) In order to improve the strength and durability of welded joints, various welding parameters and component shapes must be considered. In this study, we examined the impact of different fillet profiles on the performance and longevity of welded joints through numerical analysis using the finite element method (FEM). The fillet profiles studied included concave, convex, and fillet types, each with varying radii and slopes. The FEM analysis of each profile was thoroughly conducted, and the fatigue life of the joint was determined for each case. The complete simulation and FEM analysis results for each profile are presented in the following section. Finite element analysis (FEA) is a computational method used to analyse the behaviour of structures under different loading conditions. [1]

Sadiq Gbagba et.al. (2023) In the shipbuilding, construction, automotive, and aerospace industries, welding is still a crucial manufacturing process because it can be utilized to create massive, intricate structures with exact dimensional specifications. These kinds of structures are essential for urbanization considering they are used in applications such as tanks, ships, and bridges. However, one of the most important types of structural damage in welding continues to be fatigue. Therefore, it is necessary to take this phenomenon into account when designing and to assess it while a structure is in use. Although traditional methodologies including strain life, linear elastic fracture mechanics, and stress-based procedures are useful for diagnosing fatigue failures, these techniques are typically geometry restricted, require a lot of computing time, are not self-improving, and have limited automation capabilities. [2]

David Äse and Filip Anderfelt (2022) The use of recommended S-N curves, presented in current literature, to analyse and determine the fatigue life of a part is common practice in, inter alia, the construction industry. However, the recommended S-N curves are generally created for larger components used in mainly the construction industry. Hence, the use of S-N curves for the evaluation of smaller parts, may result in over-dimensioning of such parts. For this reason, evaluation and designing of smaller parts could benefit from the development of an in house S-N curve specific for the part. The purpose of this thesis is to generate and validate an in-house method for creating a S-N curve, for a specific part to be compared with recommended S-N curves in the literature. The specific part used for the generating of the method is a welded steel joint with the geometry of two steel pipes, welded together in a t-formation and which has been provided by Thule AB for the purpose of the thesis. [3]

T. Marin and G. Nicoletto (2021) Fatigue design of welded structures is primarily based on a nominal stress; hot spot stress methods or local approaches each having several limitations when coupled with finite element modeling. An alternative recent structural stress definition is discussed and implemented in a post-processor. It provides an effective means for the direct coupling of finite element results to the fatigue assessment of welded joints in complex structures. The applications presented in this work confirm the main features of the method: mesh-insensitivity, accurate crack location and life to failure predictions. [4]

Tone Wermundsen (2021) Fatigue analysis with non-linear loading conditions, such as wind and waves, is a complicated process that requires thoroughly groundwork of the structural design. For such structures, weld lines in joints are particular hard to assess. This thesis will provide a study of the processes described in both recommended practices, and start to present a solution to automate the processes of doing fatigue calculations, by creating extensions for the engineering simulation software ANSYS. The DNV Fatigue Toolbar presented provides tools for evaluating fatigue in base material and joints in both the high and low cycle region. [5]

Ronaldo Cesar Tremarin et.al. (2020) This work presents a new computational approach to estimate the fatigue life in welded joints, taking into account three-dimensional, non-proportional, and out-of-phase stresses; the thermomechanical properties of steel; parameters of the welding process; and the effects of residual stresses. We use the mechanical equations of continuous and cumulative fatigue damage found from Multi axial Rain Flow, the Wang and Brown and critical plane methods, and the Findley criteria approach. The numerical finite element method, available with software, is used to simulate the formation of residual stress and quantify its influence by solving equations. [6]

Ibrahim Alachek et.al. (2020) This paper seeks to characterize the "Push out" shear test to enhance understanding of how various geometrical parameters influence the shear strength of adhesive joints. The study involves both experimental and numerical analyses to assess the impact of factors such as surface treatment, GFRP profile shape, dimensions of adherents (width and thickness), adhesive thickness, bonded length, and free height on the failure load and failure mode of specimens. The numerical investigations utilize a three-dimensional (3D) nonlinear Finite Element (FE) model. The pultruded GFRP's constitutive relationship is represented using a linear orthotropic law, while the concrete behavior is defined by an elastic-plastic damage model with a non-local formulation. [7]

S A Afolalu et. al. (2019) In the manufacturing industry today, welding is a very important process needed for fabrications and revamping metal products. Researchers continually look for the best types of welding to be used for various joints. A lot of experiments had been carried out varying welding parameters and studying its effects. This paper basically reviews the residual stress effects on the welded joints of Steel, Magnesium and Aluminium alloy with their experimental analysis. The performances comparison of TIG, MIG and Friction Stir welding were also considered through check of their microstructure, mechanical property, young modulus, stress and yield stress of their welded joints. This has been able to show different behavious resulted from various welding mode of a welded joint. [8]

A. Chennakesava Reddy (2019) The purpose of this work was to assess three joints, namely vee-joint, square joint and plain joint, used for joining of dissimilar mild steel and austenite stainless steel materials by continuous drive friction welding. Three joints were evaluated for their strength, hardness, fatigue life, heat affected zone and metal flow across the weld joints. This article dealt with complete failure data (all samples were tested until they failed). The vee-joint found to be the superior alternative for the dissimilar materials in continuous drive friction welding. [9]

Objectives: Conduct an extensive review of existing literature on welded joint longevity, emphasizing studies involving different edge profiles. Explore the historical development of welding techniques and their impact on the fatigue performance of joints.

- Understanding FEM.
- Identification of Key factors influencing fatigue performance.
- Numerical Simulation and analysis.

3. METHODOLOGY

The issue highlighted in this statement revolves around the deterioration in the performance of welded joints attributed to stress concentration at the component's welding-end, resulting in diminished strength and durability of the joint. The suggested remedy entails adopting a fillet profile during welding to mitigate or reposition stress concentration, consequently enhancing the joint's strength. The primary aim is to refine welding parameters, ultimately optimizing, and bolstering the performance of welded joints.

- Conduct a study on welded joints and their life criteria.
- Conduct a literature survey to identify the different process parameters that affect the fatigue life of joints.
- Develop a Finite Element Method (FEM) analysis model of the joint based on the experimental analysis performed by Cui et al.
- Develop a solid model of the joint based on the parameters mentioned during the experimental analysis.

4. CONCLUSION

In conclusion, this review paper has undertaken a comprehensive examination of the development and assessment of the longevity of welded joints, focusing on the influence of varied edge profiles through the Finite Element Method (FEM). Through an extensive literature review, we explored the historical evolution of welding techniques and their implications for the fatigue performance of joints. The study also provided an in-depth analysis of the capabilities and limitations of FEM as a numerical tool for simulating complex interactions in welded joints. The systematic identification and analysis of key factors influencing fatigue performance, including concave shapes with different arc radii, chamfering with varying radii, and the positioning of these profiles, have enriched our understanding of the intricacies involved. The conducted numerical simulations facilitated a quantitative assessment of the impact of different edge profiles on the fatigue life of welded joints, revealing insights into optimal configurations for enhanced longevity.

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