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Influence of defect geometry on putty performance in pipeline composite repair assessments

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A R T I C L E I N F O

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A B S T R A C T

The effective repair of pipelines is crucial to ensuring the integrity of infrastructure. However, the effect of defect geometries on the efficiency of pipeline composite repair systems is a major concern in the industry. This study investigated the effects of geometric properties on the performance of composite repaired pipes and putty components in the context of the efficiency of composite repair systems using parametric analysis with various defect geometries as well as two putty formulations. The study involved the development of a finite element model and the analysis of numerical simulations based on a statistical experimental design matrix. Specifically, a design of experiments approach with a specific emphasis on response surface methodology utilizing the Box–Behnken design was employed to identify factor settings tailored to different defect geometries. The analysis revealed that defect depth, length, and width had a significant negative impact on the strength of putty. Defect depth had a greater impact on the putty performance and steel pipe burst pressure compared to defect length and width. However, defect length and width had mixed influences on putty performance, with different geometries resulting in different responses for both types of putty, indicating the existence of complex interactions between these two parameters. The strength capacity of Putty-A in the repair system was significantly influenced by the interaction between defect width, depth, and length, while Putty-B, the interaction was more significant when it came to length and width of the defect. Further statistical analysis confirmed the individual significance of defect depth, length, and width, as well as their interactions on putty strength capacity. The increased sensitivity of Putty-A to changes in defect geometry compared to Putty-B introduces further complexity to material considerations. These findings highlight the importance of selecting appropriate putty properties depending on the defect geometry for effective pipeline repair. This research provides valuable insights that will guide material selection and the development of new putty material, improving the resilience and reliability of future pipeline repair technologies.

1. Introduction

The ongoing battle against corrosion and defects in oil and gas pipeline infrastructure is a constant challenge for operators and service providers. Pipeline integrity, which is critical for resource transportation, is frequently jeopardized by corrosion-induced defects, which can lead to leaks and other structural vulnerabilities [1]. Traditional repair methods, such as the replacement of damaged sections, are expensive and time-consuming and have prompted the industry to seek alternative repair methods [2].

To address these challenges, pipeline composite repair systems known as Fiber-Reinforced Polymer (FRP) composites have emerged as promising solutions, allowing for rapid restoration of pipeline integrity while minimizing disruption [2]. These systems, which typically consist of composite wrappers and putty material, have gained popularity due to their ability to enable quick repairs, reducing the risks associated with extended downtime and fluid leakage [3–6]. However, despite these benefits, the use of composite repair systems has its own set of issues, including cost implications, complicated installation (particularly in congested areas), and the need for meticulous engineering assessments

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