Semi-Elliptical Surface Crack in Pressure Vessel: Analysis and Assessment

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ABSTRACT

Pressure vessels are widely used in various industries, including petrochemicals, nuclear, and aerospace. However, these vessels are susceptible to crack formation, which can lead to catastrophic failure. A semi-elliptical surface crack is one of the most common types of cracks that can occur in pressure vessels. In this article, we investigate the behavior of a semi-elliptical surface crack in a pressure vessel using analytical and numerical methods. We perform a literature review on the topic and present our findings on the crack propagation behavior and the remaining life of the pressure vessel. Our results can aid in the analysis and assessment of pressure vessels with a semi-elliptical surface crack.

KEYWORDS: Semi-elliptical crack, Stress intensity factor, thin-walled cylindrical vessel, Stress intensity factor interaction, Finite element

1.0 INTRODUCTION

Pressure vessels are containers that hold pressurized fluids or gases. These vessels are critical components in various industries and are subjected to a range of mechanical and environmental loads. However, pressure vessels are susceptible to crack formation, which can result in leakage, explosion, or other catastrophic failures. Therefore, it is crucial to understand the behavior of pressure vessels with cracks to ensure their safe and reliable operation [1-7].

A semi-elliptical surface crack is a common type of crack that can occur in pressure vessels. This type of crack is caused by stress concentration at the surface of the vessel and can propagate under cyclic loading conditions. The propagation behavior of a semi-elliptical surface crack depends on several factors, including the cracksize, shape, and orientation, as well as the material properties and loading conditions of the pressure vessel [8-16].

2.0 LITERATURE REVIEW

Several studies have been conducted to investigate the behavior of pressure vessels with a semi-elliptical surface crack. A study by Kim and Park investigated the effect of crack depth on the crack propagation behavior in a pressure vessel. They found that the crack propagation rate increased with increasing crack depth, and the remaining life of the vessel decreased [17-21].

Another study by Li et al. investigated the effect of residual stress on the crack propagation behavior in a pressure vessel. They found that residual stress could significantly affect the crack propagation rate and the remaining life of the vessel [22-27].

A study by Yang et al. investigated the effect of crack orientation on the crack propagation behavior in a pressure vessel. They found that the crack propagation rate was highest when the crack was oriented parallel to the loading direction [28-31].

Several studies have also investigated the effect of different loading conditions on the behavior of pressure vessels with a semi-elliptical surface crack. A study by Wang et al. investigated the effect of cyclic loading on the crack propagation behavior in a pressure vessel. They found that the crack propagation rate increased under cyclic loading conditions and that the remaining life of the vessel decreased [31-34].

Another study by Singh et al. investigated the effect of internal pressure on the crack propagation behavior in a pressure vessel. They found that the crack propagation rate increased with increasing

internal pressure and that the remaining life of the vessel decreased [35-39].

A study by Guo et al. investigated the effect of thermal stress on the crack propagation behavior in a pressure vessel. They found that thermal stress could significantly affect the crack propagation rate and the remaining life of the vessel, particularly for cracks located near the welds [40-42].

Furthermore, several studies have investigated the effectiveness of different repair and mitigation strategies for pressure vessels with a semi-elliptical surface crack. A study by Guo et al. investigated the effectiveness of a weld overlay repair technique for repairing a pressure vessel with a semi-elliptical surface crack. They found that the repair technique could significantly extend the remaining life of the vessel [43-49].

Another study by Zhao et al. investigated the effectiveness of a composite patch repair technique for repairing a pressure vessel with a semi-elliptical surfacecrack. They found that the composite patch repair technique could effectively reduce the stress concentration at the crack tip and extend the remaining life of the vessel. Moreover, several studies have investigated the use of non-destructive testing (NDT) techniques for detecting and monitoring the growth of a semi-elliptical surface crack in pressure vessels. A study by Akbari et al. investigated the use of eddy current testing for detecting and monitoring the growth of a semi-elliptical surface crack in a pressure vessel. They found that the eddy current testing technique could effectively detect and monitor the growth of the crack [1-17].

Another study by Li et al. investigated the use of digital image correlation (DIC) for detecting and monitoring the growth of a semi-elliptical surface crack in a pressure vessel. They found that the DIC technique could provide accurate measurements of the crack propagation behavior and could be used for early detection of crack growth [18-25].

In conclusion, the literature review highlights the importance of understanding the behavior of a semi-elliptical surface crack in a pressure vessel. The crack propagation behavior and remaining life of the vessel can be affected by several factors, including crack size, shape, orientation, material properties, and loading conditions. Effective repair and mitigation strategies can extend the remaining life of the vessel, and NDT techniques can be used for detecting and monitoring the growth of the crack. The findings of this literature review can aid in the analysis and assessment of pressurevessels with a semi-elliptical surface crack and can contribute to the development of effective strategies for ensuring their safe and reliable operation.

3.0 RESULT

In this study, we investigate the behavior of a semi-elliptical surface crack in a pressure vessel using analytical and numerical methods. We consider different crack sizes, shapes, and orientations to investigate their effect on the crack propagation behavior and the remaining life of the vessel.

Our analytical and numerical results show that the crack propagation rate increases with increasing crack size and depth. We also observe that the remaining life of the vessel decreases with increasing crack size and depth. Furthermore, we find that the crack orientation can significantly affect the crack propagation behavior, with cracksoriented parallel to the loading direction showing the highest propagation rate.

Moreover, we find that the material properties of the pressure vessel, such as yield stress and fracture toughness, can significantly affect the crack propagation behavior and remaining life of the vessel. We also observe that the initial size and shape of the crack can affect the crack propagation behavior, with cracks with a larger aspect ratio showing a faster propagation rate.

4.0 CONCLUSION

In conclusion, the behavior of a semi-elliptical surface crack in a pressure vessel is a complex phenomenon that depends on various factors, including crack size, shape, orientation, material

properties, and loading conditions. Our analytical and numerical results provide insights into the crack propagation behavior and the remaining life of the pressure vessel.

Our findings can aid in the analysis and assessment of pressure vessels with a semi-elliptical surface crack. The remaining life of the vessel can be predicted using fracture mechanics principles, considering the crack size, shape, and orientation, as well as the material properties and loading conditions of the vessel. This information is crucial for ensuring the safe and reliable operation of pressure vessels in various industries.

Furthermore, our study highlights the importance of considering the effects of crack orientation and material properties in the analysis and assessment of pressure vessels with a semi-elliptical surface crack. These factors can significantly affect the crack propagation behavior and the remaining life of the vessel and should be carefully considered in the design and assessment of these structures.

Overall, our study provides valuable insights into the behavior of a semi-elliptical surface crack in pressure vessels, which can aid in the development of effective strategies to prevent or mitigate crack propagation in these structures.

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