Exploring the Consequence of Stress Concentration Elements on the Breakdown of Pressure Vessels

Obaid Paal, Sadavir Udichi, Wade Waen, Yachika Zacarias, Adalbert Baadal
Nanyang Technological University (NTU), Singapore

ABSTRACT

Pressure vessels are critical components in various industries, including oil and gas, petrochemical, and food processing. However, these vessels are prone to failure due to harsh operating conditions, including high pressure, temperature, and corrosive environments. Stress intensity factors are critical factors that can affect the failure of these vessels. In this article, we investigate the effect of stress intensity factors on the failure of pressure vessels through a comprehensive literature review and numerical simulations. Our study provides valuable insights into the effect of stress intensity factors on the failure of pressure vessels and highlights the importance of considering this factor in the design and operation of these vessels.

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

1.0 INTRODUCTION

Pressure vessels are used to store and transport fluids and gases under high pressure. These vessels are critical components in various industries, including oil and gas, petrochemical, and food processing. Due to the harsh operating conditions, including high pressure, temperature, and corrosive environments, these vessels are prone to failure. The failure of pressure vessels can have catastrophic consequences, including loss of life and property damage. Therefore, it is crucial to investigate the factors that contribute to the failure of these vessels to ensure their safe and reliable operation [1-9].

Stress intensity factors are one of the critical factors that can affect the failure of pressure vessels. These factors represent the stress concentration at a given point in a structure or component. Stress intensity factors are widely used in fracture mechanics to predict the failure of materials under different loading conditions. In the case of pressure vessels, stress intensity factors can provide valuable information about the potential failure locations and the likelihood of failure [10-18].

In this article, we investigate the effect of stress intensity factors on the failure of pressure vessels through a comprehensive literature review and numerical simulations. We summarize the existing literature on the effect of stress intensity factors on the failure of pressure vessels and present the results of our numerical simulations. Our study provides valuable insights into the effect of stress intensity factors on the failure of pressure vessels and highlights the importance of considering this factor in the design and operation of these vessels [19-26].

Pressure vessels are crucial components in various industries, including oil and gas, petrochemical, pharmaceutical, and food processing. These vessels are designed to store and transport fluids and gases under high pressure and harsh operating conditions. Due to the nature of their operation, pressure vessels are prone to failure, which can have catastrophic consequences, including loss of life and property damage. Therefore, it is crucial to investigate the factors that contribute to the failure of these vessels to ensure their safe and reliable operation [27-38].

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The accurate prediction of stress intensity factors is crucial in the design and operation of pressure vessels. The failure of these vessels can occur due to various reasons, including fatigue, corrosion, and stress concentration. Stress intensity factors provide a way to evaluate the stress concentration at a given point, which is a critical factor in predicting the failure of pressure vessels. Therefore, it is essential to investigate the effect of stress intensity factors on the failure of pressure vessels to ensure their safe and reliable operation [1-9].

In this article, we investigate the effect of stress intensity factors on the failure of pressure vessels through a comprehensive literature review and numerical simulations. We summarize the existing literature on the effect of stress intensity factors on the failure of pressure vessels and present the results of our numerical simulations. Our study provides valuable insights into the effect of stress intensity factors on the failure of pressure vessels and highlights the importance of considering this factor in the design and operation of these vessels. We believe that our study will contribute to the development of safer and more reliable pressure vessels in various industries [10-18].

2.0 LITERATURE REVIEW

Several studies have investigated the effect of stress intensity factors on the failure of pressure vessels. One study by Chen et al. investigated the effect of stress intensity factors on the fatigue crack growth behavior of a pressure vessel made of austenitic stainless steel. The study found that stress intensity factors significantly affect the crack growth rate and, therefore, the fatigue life of the vessel. Another study by Kuo et al. investigated the effect of stress intensity factors on the crack propagation behavior of a pressure vessel made of high-strength low-alloy steel. The study found that stress intensity factors significantly affect the crack propagation rate and, therefore, the fracture behavior of the vessel [1-19].

In addition to the experimental studies, several numerical simulations have been conducted to investigate the effect of stress intensity factors on the failure of pressure vessels. One study by Li et al. conducted a finite element analysis to investigate the effect of stress intensity factors on the fracture behavior of a pressure vessel made of aluminum alloy. The study found that stress intensity factors significantly affect the fracture behavior of the vessel and that higher stress intensity factors result in a higher risk of failure. Another study by Sun et al. conducted a numerical simulation to investigate the effect of stress intensity factors on the fatigue life of a pressure vessel made of carbon steel. The study found that stress intensity factors significantly affect the fatigue life of the vessel and that higher stress intensity factors result in a shorter fatigue life [20-27].

Several studies have investigated the effect of stress intensity factors on the failure of pressure vessels. One study by Liu et al. investigated the effect of stress intensity factors on the fracture behavior of a pressure vessel made of aluminum alloy. The study found that stress intensity factors significantly affect the fracture behavior of the vessel and that higher stress intensity factors result in a higher risk of failure. Another study by Lee et al. investigated the effect of stress intensity factors on the fatigue crack growth behavior of a pressure vessel made of high-strength low-alloy steel. The study found that stress intensity factors significantly affect the crack growth rate and, therefore, the fatigue life of the vessel [28-33].

In addition to experimental studies, several numerical simulations have been conducted to investigate the effect of stress intensity factors on the failure of pressure vessels. One study by Yu et al. conducted a finite element analysis to investigate the effect of stress intensity factors on the fracture behavior of a pressure vessel made of duplex stainless steel. The study found that stress intensity factors significantly affect the fracture behavior of the vessel, and that the presence of corrosion further increases the risk of failure. Another study by Li et al. conducted a numerical simulation to investigate the effect of stress intensity factors on the fatigue life of a pressure vessel made of titanium alloy. The study found that stress intensity factors significantly affect the fatigue life of the vessel, and that higher stress intensity factors result in a shorter fatigue life [34-39].

Overall, the literature suggests that stress intensity factors are a critical factor in predicting the failure of pressure vessels. Both experimental studies and numerical simulations have shown that stress intensity factors significantly affect the fracture behavior and fatigue life of pressure vessels. Therefore, it is essential to consider stress intensity factors in the design and operation of pressure vessels to ensure their safe and reliable operation. Further research can investigate the effect of stress intensity factors on the failure of pressure vessels under different operating conditions and materials to provide a comprehensive understanding of this critical factor. Such research can help to develop more accurate and reliable models for predicting the failure of pressure vessels, which can lead to safer and more efficient pressure vessels in various industries [35-49].

3.0 RESEARCH METHODOLOGY

To investigate the effect of stress intensity factors on the failure of pressure vessels, we conducted a comprehensive literature review and numerical simulations using finite element analysis. The research methodology is described below:

1. Literature Review:

We conducted a comprehensive literature review of existing studies investigating the effect of stress intensity factors on the failure of pressure vessels. The review included experimental studies, numerical simulations, and analytical models. We analyzed the findings of the studies and identified the critical factors that affect the stress intensity factors and the failure of pressure vessels.

2. Design and Modeling of Pressure Vessel:

We designed and modeled a pressure vessel using a computer-aided design (CAD) software. The vessel was made of carbon steel and had a cylindrical shape with hemispherical ends. The dimensions of the vessel were chosen based on standard industry practices.

3. Finite Element Analysis:

We conducted a finite element analysis (FEA) using a commercial software package to simulate the behavior of the pressure vessel under different loading conditions. The FEA model included the geometry of the vessel, the material properties, and the boundary conditions. We used the ANSYS software package for the FEA simulations.

4. Determination of Critical Locations:

We identified the critical locations in the vessel where stress intensity factors were expected to be high. These locations were identified based on the geometry of the vessel and the expected stress concentration.

5. Variation of Stress Intensity Factors:

We varied the stress intensity factors at the critical locations in the vessel by changing the external loading conditions. We varied the pressure and temperature of the fluid inside the vessel to simulate the effect of different operating conditions on the stress intensity factors.

6. Evaluation of Failure:

We evaluated the failure of the vessel by analyzing the stress intensity factors at the critical locations and comparing them to the critical stress intensity factor for the material. We also analyzed the deformation and strain of the vessel to identify any signs of failure.

7. Sensitivity Analysis:

We conducted a sensitivity analysis to investigate the effect of different parameters on the stress intensity factors and the failure of the vessel. We varied the material properties, the vessel dimensions, and the loading conditions to investigate their effect on the stress intensity factors and the failure of the vessel.

8. Data Analysis:

We analyzed the data obtained from the simulations using statistical tools and visualization techniques. We compared the results of the simulations to the existing literature to validate our findings.

The research methodology described above allowed us to investigate the effect of stress intensity factors on the failure of pressure vessels through a comprehensive literature review and numerical simulations. The methodology can be extended to investigate the effect of stress intensity factors on the failure of pressure vessels made of different materials and under different operating conditions.

4.0 RESULT

To investigate the effect of stress intensity factors on the failure of pressure vessels, we conducted a numerical simulation using finite element analysis. The simulation was performed on a pressure vessel made of carbon steel. We varied the stress intensity factors at critical locations in the vessel and evaluated the effect on the failure of the vessel.

Our results showed that stress intensity factors significantly affect the failure of pressure vessels. At higher stress intensity factors, the vessel was more prone to failure, indicating the critical role of this factor in predicting the failure of pressure vessels. We also conducted a sensitivity analysis and found that the material properties, vessel dimensions, and loading conditions significantly affect the stress intensity factors and the failure of the vessel.

5.0 CONCLUSION

In conclusion, stress intensity factors are a critical factor in predicting the failure of pressure vessels. Our study investigated the effect of stress intensity factors on the failure of a pressure vessel made of carbon steel through numerical simulations. The results showed that stress intensity factors significantly affect the failure of pressure vessels. Therefore, it is essential to consider this factor in the design and operation of pressure vessels to ensure their safe and reliable operation. Our study provides valuable insights into the effect of stress intensity factors on the failure of pressure vessels and highlights the importance of considering this factor in the design and operation of these vessels. Further research can investigate the effect of stress intensity factors on the failure of pressure vessels made of different materials and operating conditions to provide a comprehensive understanding of this critical factor.

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