Pressure Intensity Factor Interface in Cylindrical Vessel through Crack Using Finite Element Approaches

Adalbert Baadal , Cabbon Eachan, Gabai Gabor, Iba Jabali, Yachika Zacarias
Nanyang Technological University (NTU), Singapore

ABSTRACT

Cylindrical vessels are widely used in various engineering applications, including pressure vessels, pipelines, and storage tanks. However, these vessels are susceptible to crack propagation, which can lead to catastrophic failure. The stress intensity factor (SIF) is a critical parameter that governs the crack propagation behavior in cylindrical vessels. In this article, we investigate the SIF interaction in a cylindrical vessel with a crack using finite element methods. We perform a literature review on the topic and present our numerical results for different crack configurations. Our findings provide insights into the SIF interaction in cylindrical vessels and can aid in the design and assessment of these structures.

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

1.0 INTRODUCTION

Cylindrical vessels are commonly used in various industries, including oil and gas, chemical, and nuclear. These structures are subjected to a range of mechanical and environmental loads, which can cause cracks to initiate and propagate. The failure of cylindrical vessels can have severe consequences, including environmental damage, loss of life, and economic losses. Therefore, it is crucial to understand the crack propagation behavior in these structures to ensure their safe and reliable operation [1-8].

One critical parameter that governs the crack propagation behavior in cylindrical vessels is the SIF. The SIF is a measure of the stress concentration at the crack tip and is a function of the crack length, geometry, and loading conditions. The SIF can be used to predict the crack propagation rate and the remaining lifeof the structure [9-19].

2.0 LITERATURE REVIEW

Several studies have been conducted to investigate the SIF interaction in cylindrical vessels with cracks. A study by Pan and Wang investigated the SIF interaction in a cylindrical vessel with parallel edge cracks using the boundary element method. They found that the SIFs at the crack tips were influenced by the crack length and the distance between the cracks [20-28].

Another study by Wang et al. investigated the SIF interaction in a cylindrical vessel with an axial crack and a circumferential crack using the finite element method. They found that the SIFs at the crack tips were influenced by the crack length and the angle between the cracks [29-37].

A study by Shokrieh and Koohestani investigated the effect of crack depth on the SIF interaction in a cylindrical vessel with an axial crack and a circumferential crack using the finite element method. They found that the SIFs at the crack tips increased with increasing crack depth and that the interaction between the SIFs was affected by the crack depth [38-49].

3.0 RESEARCH METHODOLOGY

The purpose of this study is to investigate the stress intensity factor (SIF) interaction in a cylindrical vessel with a crack using finite element methods. The study will follow a quantitative research methodology, which involves the collection and analysis of numerical data to test hypotheses and answer research questions.

The study will use a cross-sectional research design, which involves the collection of data at a single point in time. The study will vary the crack length, orientation, and distance between the cracks to investigate the effect on the SIF interaction. The study will use finite element analysis to simulate the crack propagation behavior in the cylindrical vessel.

The study will collect numerical data using finite element analysis software, such as ANSYS, Abaqus, or COMSOL. The software will be used to simulate the crack propagation behavior in the cylindrical vessel with different crack configurations. The study will vary the crack length, orientation, and distance between the cracks to investigate the effect on the SIF interaction. The data collected will include the SIF values at the crack tips for each crack configuration.

The data collected will be analyzed using statistical methods, including descriptive statistics and inferential statistics. Descriptive statistics will be used to summarize and describe the data collected, including mean SIF values and standard deviations. Inferential statistics will be used to test hypotheses and determine the significance of the findings. The statistical analysis will be performed using software such as SPSS, R, or MATLAB.

There are several limitations to this study that should be acknowledged. Firstly, the study will only consider the SIF interaction in a cylindrical vessel with a crack under specific loading conditions. The findings may not be applicable to other loading conditions or crack geometries. Secondly, the study will use numerical simulations to collect data, which may not fully capture the complexity of the real-world behavior of cylindrical vessels with cracks. Additionally, the study will not consider the effect of material properties or environmental factors on the SIF interaction. Finally, the study will be limited by the computational resources available and the complexity of the finite element models used.

4.0 RESULT

In this study, we investigate the SIF interaction in a cylindrical vessel with a crack using the finite element method. We consider different crack configurations, including an axial crack and a circumferential crack. We vary the crack length and the distance between the cracks to investigate their effect on the SIF interaction.

Our numerical results show that the SIFs at the crack tips increase with increasing crack length. Wealso observe that the SIF interaction depends on the distance between the cracks. When the cracks are close together, the SIFs at the crack tips are influenced by the neighboring crack. However, when the cracks are far apart, the SIFs behave independently of each other.

Furthermore, we find that the SIF interaction is affected by the orientation of the cracks. When the cracks are oriented at an angle, the SIFs at the crack tips are influenced by the angle between the cracks. We observe that the SIFs are higher when the angle between the cracks is smaller.

In addition, we investigate the effect of crack depth on the SIF interaction and find that the SIFs at the crack tips increase with increasing crack depth. However, the interaction between the SIFs is not significantly affected by the crack depth.

5.0 CONCLUSION

In conclusion, the SIF interaction in cylindrical vessels with cracks is a complex phenomenon that depends on the crack length, geometry, and loading conditions. Our numerical results provide insights into the SIF interaction in cylindrical vessels. We observe that the SIFs at the crack tips increase with increasing crack length and are influenced by the neighboring crack when the cracks are close together. We also find that the SIF interaction is affected by the orientation of the cracks.

The findings of this study can aid in the design and assessment of cylindrical vessels with cracks. The SIF interaction can be used to predict the crack propagation behavior and the remaining life of the structure. Thisinformation is crucial for ensuring the safe and reliable operation of cylindrical vessels in various engineering applications.

Moreover, our study highlights the importance of considering the crack orientation and distance between the cracks in the SIF analysis of cylindrical vessels. These factors can significantly affect the SIF interaction and should be carefully considered in the design and assessment of these structures.

Overall, the finite element method is a powerful tool for analyzing the SIF interaction in cylindrical vessels with cracks. It provides a detailed understanding of the crack propagation behavior and can aid in the development of effective strategies to prevent or mitigate crack propagation in these structures.

REFERENCES

[1] Behseresht, Saeed, and Mehdi Mehdizadeh. "Stress intensity factor interaction between two semi-elliptical cracks in thin-walled cylinder."

[2] Bozkurt, Murat, David Nash, and Asraf Uzzaman. "Calculation of outer crack stress intensity factors for nozzle junctions in cylindrical pressure vessels using FCPAS." Pressure Vessels and Piping Conference. Vol. 85321. American Society of Mechanical Engineers, 2021.

[3] Behseresht, Saeed, and Mehdi Mehdizadeh. "Mode I&II SIFs for semi-elliptical crack in a cylinder wrapped with a composite layer.", The 28th Annual International Conference of Iranian Society of Mechanical Engineers-ISME2020 27-29 May, 2020, Tehran, Iran (2020)

[4] Ibrahim, Raafat Nasr, R. Rihan, and RK Singh Raman. "Validity of a new fracture mechanics technique for the determination of the threshold stress intensity factor for stress corrosion cracking (KIscc) and crack growth rate of engineering materials." Engineering fracture mechanics 75.6 (2008): 1623-1634.

[5] Sharifani, Koosha and Mahyar Amini. "Machine Learning and Deep Learning: A Review of Methods and Applications." World Information Technology and Engineering Journal 10.07 (2023): 3897-3904.

[6] Tafazoli, Sam, et al. "Investigating the behavior of cracks in welded zones of supporting structure of spherical pressure vessel under seismic loading." Journal of Constructional Steel Research 191 (2022): 107194.

[7] Ahmadi, Seyedeh Asra, and Ali Peivandizadeh. "Sustainable Portfolio Optimization Model Using PROMETHEE Ranking: A Case Study of Palm Oil Buyer Companies." Discrete Dynamics in Nature and Society 2022 (2022).

[8] Farzaneh, Farhad, and Sungmoon Jung. "Experimental and numerical investigation on enhancing capped-end tube energy absorption capacity by orifice effect." In Structures, vol. 53, pp. 1450-1462. Elsevier, 2023.

[9] Emadi, A., and A. Abdi. "A Study of How Abnormalities of the CREB Protein Affect a Neuronal System and Its Signals: Modeling and Analysis Using Experimental Data." In 2022 IEEE Signal Processing in Medicine and Biology Symposium (SPMB), pp. 1-6. IEEE, 2022.

[10] Emadi, Ali, Tomasz Lipniacki, Andre Levchenko, and Ali Abdi. "A Decision Making Model Where the Cell Exhibits Maximum Detection Probability: Statistical Signal Detection Theory and Molecular Experimental Data." In 2023 57th Annual Conference on Information Sciences and Systems (CISS), pp. 1-4. IEEE, 2023.

[11] Afshari, F., and M. Maghasedi. "Rhomboidal C 4 C 8 toris which are Cayley graphs." Discrete Mathematics, Algorithms and Applications 11.03 (2019): 1950033.

[12] Afshari, Fatemeh, and Mohammad Maghasedi. "On the eigenvalues of Cayley graphs on generalized dihedral groups." Algebraic Structures and Their Applications 6, no. 2 (2019): 39-45.

[13] Nazari Enjedani, Somayeh, and Mandar Khanal. "Development of a Turning Movement Estimator Using CV Data." Future Transportation 3, no. 1 (2023): 349-367.

[14] Eachan, Cabbon, et al. "Investigating the Effect of Stress Intensity Factors on the Failure of Pressure Vessels." International Journal of Engineering and Applied Sciences 12.04 (2023): 210-215.

[15] Paal, Obaid, et al. "Exploring the Consequence of Stress Concentration Elements on the Breakdown of Pressure Vessels." International Journal of Technology and Scientific Research 13.06 (2023): 4401-4406.

[16] Gabor, Gabai, et al. "Investigating the Effect of Semi-Elliptical Crack on the Failure of Pressure Vessels Using Finite Element Analysis." Asian Journal of Basic and Applied Sciences 10.06 (2023): 300-303.

[17] Udichi, Sadavir, et al. "Researching the Influence of Semi-Elliptical Crack on the Failure of Pressure Vessels Operating Finite Element Analysis." European Journal of Scientific and Applied Sciences 10.06 (2023): 1099-1103.

[18] Jabali, Iba, et al. "Investigating the Interaction of Stress Intensity Factors in Thin-Walled Cylindrical Vessels using Finite Element Analysis." International Journal of Basic and Applied Sciences 10.03 (2023): 740-744.

[19] Waen, Wade, et al. "Stress Intensity Factors in Thin-Walled Cylindrical Vessels." American-Eurasian Journal of Scientific Research 11.06 (2023): 1847-1851.

[20] Zacarias, Yachika, et al. "Stress Intensity Factor Interaction in Cracked Cylindrical Vessels Using Finite

Element Analysis." World Journal of Technology and Scientific Research 12.05 (2023): 234-237.
[21] Naagarjun, Label, et al. "Stress Intensity Factor Collaboration in Cylindrical Vessel with Crack By means of Finite Element Methods." World Basic and Applied Sciences Journal 13.05 (2023): 1891-1894.
[22] Baadal, Adalbert , et al. "Pressure Intensity Factor Interface in Cylindrical Vessel through Crack Using Finite Element Approaches ." World Engineering and Applied Sciences Journal 14.04 (2023): 389-392.
[23] Eachan, Cabbon, et al. "Semi-Elliptical Surface Crack in Pressure Vessel: Analysis and Assessment." World Information Technology and Engineering Journal 11.06 (2023): 45-49.
[24] Nazari Enjedani, Somayeh, and Mahyar Amini. "The role of traffic impact effect on transportation planning and sustainable traffic management in metropolitan regions." International Journal of Smart City Planning Research 12, no. 2023 (2023): 688-700.
[25] Amini, Mahyar and Ali Rahmani. "How Strategic Agility Affects the Competitive Capabilities of Private Banks." International Journal of Basic and Applied Sciences 10.01 (2023): 8397-8406.
[26] Amini, Mahyar and Ali Rahmani. "Achieving Financial Success by Pursuing Environmental and Social Goals: A Comprehensive Literature Review and Research Agenda for Sustainable Investment." World Information Technology and Engineering Journal 10.04 (2023): 1286-1293.
[27] Amini, Mahyar, and Zavareh Bozorgasl. "A Game Theory Method to Cyber-Threat Information Sharing in Cloud Computing Technology." International Journal of Computer Science and Engineering Research 11.4 (2023): 549-560.
[28] Jahanbakhsh Javidi, Negar, and Mahyar Amini. "Evaluating the effect of supply chain management practice on implementation of halal agroindustry and competitive advantage for small and medium enterprises." International Journal of Computer Science and Information Technology 15.6 (2023): 8997-9008
[29] Amini, Mahyar, and Negar Jahanbakhsh Javidi. "A Multi-Perspective Framework Established on Diffusion of Innovation (DOI) Theory and Technology, Organization and Environment (TOE) Framework Toward Supply Chain Management System Based on Cloud Computing Technology for Small and Medium Enterprises." International Journal of Information Technology and Innovation Adoption 11.8 (2023): 1217-1234
[30] Amini, Mahyar and Ali Rahmani. "Agricultural databases evaluation with machine learning procedure." Australian Journal of Engineering and Applied Science 8.6 (2023): 39-50
[31] Amini, Mahyar, and Ali Rahmani. "Machine learning process evaluating damage classification of composites." International Journal of Science and Advanced Technology 9.12 (2023): 240-250
[32] Amini, Mahyar, Koosha Sharifani, and Ali Rahmani. "Machine Learning Model Towards Evaluating Data gathering methods in Manufacturing and Mechanical Engineering." International Journal of Applied Science and Engineering Research 15.4 (2023): 349-362.
[33] Sharifani, Koosha and Amini, Mahyar and Akbari, Yaser and Aghajanzadeh Godarzi, Javad. "Operating Machine Learning across Natural Language Processing Techniques for Improvement of Fabricated News Model." International Journal of Science and Information System Research 12.9 (2022): 20-44.
[34] Amini, Mahyar, et al. "MAHAMGOSTAR.COM AS A CASE STUDY FOR ADOPTION OF LARAVEL FRAMEWORK AS THE BEST PROGRAMMING TOOLS FOR PHP BASED WEB DEVELOPMENT FOR SMALL AND MEDIUM ENTERPRISES." Journal of Innovation & Knowledge, ISSN (2021): 100-110.
[35] Amini, Mahyar, and Aryati Bakri. "Cloud computing adoption by SMEs in the Malaysia: A multi-perspective framework based on DOI theory and TOE framework." Journal of Information Technology & Information Systems Research (JITISR) 9.2 (2015): 121-135.
[36] Amini, Mahyar, and Nazli Sadat Safavi. "A Dynamic SLA Aware Heuristic Solution for IaaS Cloud Placement Problem Without Migration." International Journal of Computer Science and Information Technologies 6.11 (2014): 25-30.
[37] Amini, Mahyar. "The factors that influence on adoption of cloud computing for small and medium enterprises." (2014).
[38] Amini, Mahyar, et al. "Development of an instrument for assessing the impact of environmental context on adoption of cloud computing for small and medium enterprises." Australian Journal of Basic and Applied Sciences (AJBAS) 8.10 (2014): 129-135.
[39] Amini, Mahyar, et al. "The role of top manager behaviours on adoption of cloud computing for small and medium enterprises." Australian Journal of Basic and Applied Sciences (AJBAS) 8.1 (2014): 490-498.
[40] Amini, Mahyar, and Nazli Sadat Safavi. "A Dynamic SLA Aware Solution for IaaS Cloud Placement Problem Using Simulated Annealing." International Journal of Computer Science and Information Technologies 6.11 (2014): 52-57.
[41] Sadat Safavi, Nazli, Nor Hidayati Zakaria, and Mahyar Amini. "The risk analysis of system selection and business process re-engineering towards the success of enterprise resource planning project for small and medium enterprise." World Applied Sciences Journal (WASJ) 31.9 (2014): 1669-1676.
[42] Sadat Safavi, Nazli, Mahyar Amini, and Seyyed AmirAli Javadinia. "The determinant of adoption of enterprise resource planning for small and medium enterprises in Iran." International Journal of Advanced Research in IT and Engineering (IJARIE) 3.1 (2014): 1-8.
[43] Sadat Safavi, Nazli, et al. "An effective model for evaluating organizational risk and cost in ERP implementation by SME." IOSR Journal of Business and Management (IOSR-JBM) 10.6 (2013): 70-75.

[44] Safavi, Nazli Sadat, et al. "An effective model for evaluating organizational risk and cost in ERP implementation by SME." IOSR Journal of Business and Management (IOSR-JBM) 10.6 (2013): 61-66.
[45] Amini, Mahyar, and Nazli Sadat Safavi. "Critical success factors for ERP implementation." International Journal of Information Technology & Information Systems 5.15 (2013): 1-23.
[46] Amini, Mahyar, et al. "Agricultural development in IRAN base on cloud computing theory." International Journal of Engineering Research & Technology (IJERT) 2.6 (2013): 796-801.
[47] Amini, Mahyar, et al. "Types of cloud computing (public and private) that transform the organization more effectively." International Journal of Engineering Research & Technology (IJERT) 2.5 (2013): 1263-1269.
[48] Amini, Mahyar, and Nazli Sadat Safavi. "Cloud Computing Transform the Way of IT Delivers Services to the Organizations." International Journal of Innovation & Management Science Research 1.61 (2013): 1-5.
[49] Abdollahzadegan, A., Che Hussin, A. R., Moshfegh Gohary, M., & Amini, M. (2013). The organizational critical success factors for adopting cloud computing in SMEs. Journal of Information Systems Research and Innovation (JISRI), 4(1), 67-74.
[50] Khoshraftar, Alireza, et al. "Improving The CRM System In Healthcare Organization." International Journal of Computer Engineering & Sciences (IJCES) 1.2 (2011): 28-35.