INNOVATIVE: Journal Of Social Science Research
Volume 5 Nomor 2 Tahun 2025 Page 1852-1867
E-ISSN 2807-4238 and P-ISSN 2807-4246
Website: https://j-innovative.org/index.php/Innovative

Literature Review Pipe Stress Analysis in Piping System

Nanang K. Pradipta[1✉], Dafit Feriyanto[2], Muhamad Fitri[3]
Universitas Mercubuana
Email: pradipta.nanang@yahoo.com[1✉]

Abstract

Piping systems are a major component in oil and gas processing facilities in Indonesia. With piping usage increasing every year, safety is a critical priority to avoid fatalities due to piping damage. This study conducted a literature review of 51 international journals published between 2014 and 2024, focusing on factors that affect piping stresses analysis such as force loads, pipe support, piping layout, vibration, earthquake, and cryogenic service conditions. Based on this study, it was found that force load, piping layout, pipe support and vibration have impact on pipe stress. Analysis using software such as CAESAR II proved effective in identifying critical piping and ensuring the system performs with established safety standards. The review shows that piping stress analysis not only maintains safe operational limits but also improves piping reliability. With proper application of stress analysis, the risk of failure can be minimized and reliability of the piping system increased.

Keywords: *Loads, Pipe Stress Analysis, Piping System, Piping Layout, Pipe Support*

Abstrak

Sistem perpipaan merupakan komponen utama dalam fasilitas pemrosesan minyak dan gas di Indonesia. Dengan meningkatnya penggunaan perpipaan setiap tahunnya, keselamatan menjadi prioritas penting untuk menghindari kematian akibat kerusakan perpipaan. Penelitian ini melakukan telaah pustaka terhadap 51 jurnal internasional yang diterbitkan antara tahun 2014 dan 2024, dengan fokus pada faktor-faktor yang memengaruhi analisis tegangan perpipaan seperti beban gaya, tumpuan pipa, tata letak perpipaan, getaran, gempa bumi, dan kondisi layanan kriogenik. Berdasarkan penelitian ini, ditemukan bahwa beban gaya, tata letak perpipaan, tumpuan pipa, dan getaran berdampak pada tegangan pipa. Analisis menggunakan perangkat lunak seperti CAESAR II terbukti efektif dalam mengidentifikasi perpipaan kritis dan memastikan sistem bekerja dengan standar keselamatan yang ditetapkan. Tinjauan tersebut menunjukkan bahwa analisis tegangan perpipaan tidak hanya mempertahankan batas operasional yang aman tetapi juga meningkatkan keandalan perpipaan. Dengan penerapan analisis tegangan yang tepat, risiko kegagalan dapat diminimalkan dan keandalan sistem perpipaan meningkat.

Kata Kunci: *Beban, Analisis Tegangan Pipa, Sistem Perpipaan, Tata Letak Perpipaan, Dukungan Pipa*

INTRODUCTION

Piping systems are essential components in fluid transportation within industrial processes. A well designed piping system plays a critical role in safeguarding the entire facility, as it ensures the safe and efficient transportation of fluids. In order to guarantee safety and functionality, detailed engineering and analysis are required during the design phase. Specifically, the routing of pipes must be carefully planned to accommodate fluid pressure and temperature, as well as other operational conditions (Prabhu Kishore & Prabhu, 2018).

The piping design mainly depends on stress analysis, which ensures that the routing, nozzle loads, hangers, and supports are properly placed and designed to withstand various stresses without exceeding the allowable limits. For process and power piping systems, stress analysis also evaluates the mechanical behavior of the piping under regular loads such as internal pressure and thermal stresses, as well as under occasional and intermittent loads, including those caused by earthquakes, wind, special vibrations, and water hammer (Bisht & Jahan, 2014).

In the context of Indonesia, the rapid expansion of oil and gas pipelines, as shown by the increasing length of pipelines from 2018 to 2022, emphasizes the importance of performing comprehensive pipe stress analysis. As the infrastructure grows, ensuring safety and reliability through optimized pipe design becomes essential. This study aims to explore

the methods used in pipe stress analysis, emphasizing the significance of optimizing pipeline configurations to improve flexibility and ensure safe operation. The increase in the use of pipelines in the oil and gas industry in Indonesia is increasing from 2018 to 2022 according to the figure below

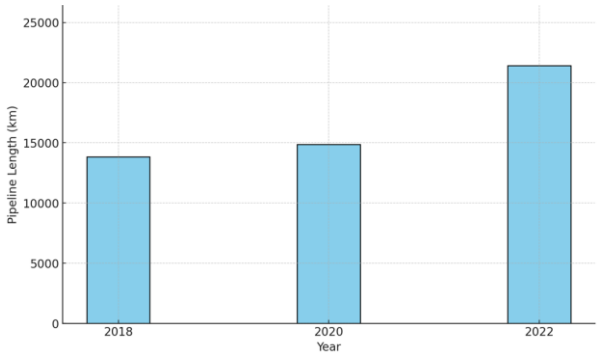

Fig 1. Pipeline Length vs Year (Growth of natural gas pipeline BPH Migas)

The purpose of this study to explore pipe stress analysis methods, emphasizing the importance of optimizing design configurations to improve pipeline flexibility and ensure safety for operation in industrial environments. The increasing length of natural gas pipelines in Indonesia, as shown in the histogram, it require pipe stress analysis to ensure safety and reliability for expanding pipeline infrastructure.

METHODOLOGY

In this study, a comprehensive review of 51 sources journal articles of literature was conducted. Base on review journal there are 5 category which impact to lead failure in pipe stress analysis, 23 articles piping force loads, 8 articles pipe supports, 7 articles pipe layout, 8 articles piping vibration, 3 articles piping earthquake, 3 articles piping cryogenic services.

Figure 2 is representing the impact on pipe stress analysis based on the provided data. Each segment corresponds to a specific factor affecting pipe stress, with the percentage reflecting its relative impact.

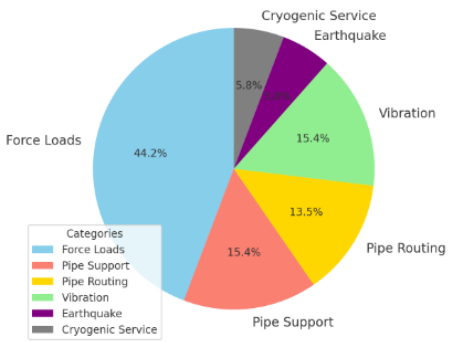

Fig 2. Percentage Impact Category on Pipe Stress Analysis

Based on 51 articles review illustrating the pipe stress analysis for piping systems connected to equipment at figure 3 below

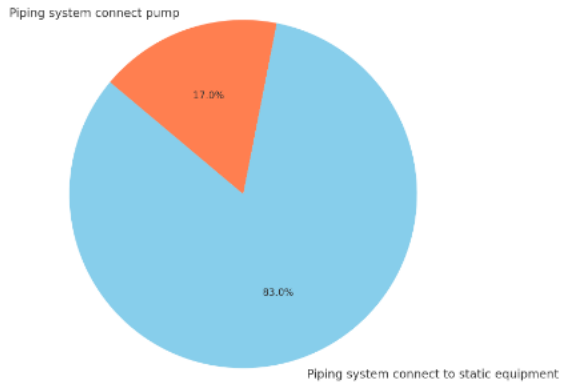

Fig 3. Piping System Connect to Equipment Type

Review of Force Load Impact to Pipe Stress Analysis

According to the basic characteristics of the stress, which fall into three categories, including primary stress, secondary stress and operating stress. From that study result max stress for multiple stress, primary stress and secondary stress is 87.7 % from allowable stress (X. N. Wu, Wu, et al., 2014). The load due to the temperature and self-weight of the piping installed on the deck is also considered. Various operating and load conditions of the LNG piping system are analyzed. Stress analysis is performed by combining various conditions of sustained, occasional, and expansion loads. Stress is assessed using finite element analysis based on beam elements that represent the behavior of the piping. The attributes of the piping system components (such as valves, expansion joints, and supports) are represented in the finite element model while CAESAR-II, a commercial software is used for finite element analysis (Hwang et al., 2020).

Studies related to force load impact to pipe stress analysis according to study type and objective at table below

Table 1. Force Load Impact to Pipe Stress Analysis

Ref.	Study Type	Research Objective
Bisht & Jahan, 2014	Experimental	Analyze abilities and backgrounds in stress
Prabhu Kishore & Prabhu, 2018	Experimental	Stress analysis methode of a pump piping system
Hwang et al., 2020	Experimental	Evaluated stress for piping LNG as per ASME

Arun et al., 2016	Experimental	Analysis thermal expansion loop using Caesar II
Sharma Ȧ et al., 2014	Experimental	Explain concept of flexibility stress
Bhatia & Jha, 2014	Theoretical	Analytical method of piping thickness and stress under sustained loading
B. Li et al., 2020	Experimental	Advantages and problems of CAESARII stress analysis software
X. N. Wu, Wu, et al., 2014)	Experimental	Impact of changes in temperature and pressure on piping stress
X. Wu, Lu, & Wu, 2015	Experimental	Stress and displacement of parallel oil and gas pipelines that run through tunnels
Sohail et al., 2017	Experimental	Ensure stresS in the piping components of the system are within the allowable limits
Gu et al., 2021	Experimental	calculating the strength of lined composite pipe was not given in the pipeline stress analysis standards.
Bisht & Dodeja, 2015	Experimental	Simulation model is analyzed under varying uncertainty conditions
Verma et al., 2019	Experimental	The high temperature piping network is analyzed for sustained and occasional load
Buddhe, 2018	Experimental	Flexibility analysis of extraction piping of duplex heater
Huang et al., 2015)	Experimental	Stress of pipelines in high and steep slope areas was analyzed operating conditions
Aswin et al., 2024	Experimental	Evaluate stress of the selection of bends on the pipeline
Rao et al., 2021	Experimental	Investigation was carried out to understand the different loads acting on the piping system
Ju et al., 2014	Experimental	Carrying a rigid pipeline thermal expansion load and the other end is connected to a flexible riser
Kim et al., 2022	Experimental	A piping system stress analysis for structural integrity assessment after reinforcement of a pipe wall thinning
Verma et al., 2018)	Experimental	Performed for sustained and occasional load combinations for various ITER operating states
Ye et al., 2023	Experimental	Stress analysis of the special large-aperture nozzle pipeline designed in a boiler design process
Raafat et al., 2019	Experim	Combined analysis was carried out using the finite element

	ental	method by means of ANSYS software
Choudhury, 2016)	Experim ental	Piping flexibility analysis piping ambient connect piping system operating.

Review of Pipe Support Impact to Pipe Stress Analysis

The main reason for the analysis of stresses on a piping system is to ensure that the piping is well supported and does not fall or deflect under its own weight and also to ensure that the deflection is under the limit when thermal loading takes place. Stress analysis determines the forces exerted in the pipe, anchor points, restrains in piping system, stress induced in pipe must be checked against the allowable limits (Gengadevi, 2020).

The study aims to evaluate the stress and the effect of using pipe supports on the stress in the piping system. The findings revealed that the type of support chosen, such as the gap and distance of pipe support, has a significant impact on the stress value in the piping system. The results of the analysis are carried out several times to get the stress value so that it does not exceed the allowable stress (Aswin & Hasnan, 2023). The selection and location of these supports is based on the results obtained from displacement, stress, reaction and equipment nozzle analysis of the piping system. The design is in accordance with ASME B31.3, which is the standard code for process piping. The proposed method can be adapted for piping configuration of any industrial plant. With the provision of a systematic procedure, the method ensures time saving and efficient flexibility analysis of any piping system (Zahid et al., 2018).

Studies related to pipe support impact to pipe stress analysis according to study type and objective at table below

Table 2. Pipe Support Impact to Pipe Stress Analysis

Ref.	Study Type	Research Objective
Gengadevi, 2020	Experim ental	Analysis of stresses piping system to ensure piping is well supported
Aswin & Hasnan, 2023	Experim ental	Evaluate stress and effect of using pipe supports on stress in piping system
Zahid et al., 2018	Experim ental	Selection and location of supports is based on stress results
Cardinal & Burnside, 2017	Experim ental	Piping stress analysis is to provide adequate flexibility in buried or restrained condition
Sohail et al.,	Experim	Stress analysis is a critical component of piping design through

2017	ental	parameters such as piping safety, support location
Dizdar et al., 2018	Experimental	Qualify pipe support according to the standard ASME NF-3200
Mukherjee et al., 2017	Theoretical	Stress analysis of smart support system for a steam pipeline
Ilinca & Vasilescu, 2014	Experimental	Method that allows the calculation of the recommended geometry of a trunnion support

Review of Pipe Layout Impact to Pipe Stress Analysis

Flexibility of piping system is mainly dependent on the Equipment Layout. While finalizing the location of equipments, the connecting piping flexibility is also to be considered alongwith the process flow, accessibility to valves, instruments, equipment maintenance, cleaning, operational safety, headroom clearance and aesthetics. The piping layout designer has to undergo number of iterations to reach to a final layout. Pipe Routing is always decided based on the Equipment layout. The best possible pipe routing is achieved by knowing the process flow and the above criterion for layout (Prachi et al., 2014).

During the design phase of a pipe rack for petrochemical plant which consists of thousands of piping systems, approximating these loop dimensions are a major concern for the designers. A combination of different design cases has to be considered while optimizing the loop dimensions. The design will have an impact on the design, material cost and safety of the plant. In the project, dimensions of pipe rack loops for a process plant are optimized based on temperature, pipe size, pressure etc. The guidelines mentioned in ASME B 31.3 are used for designing the loops using Caesar II Software which is based on FEM) (Sarath Sankar & Senthil Kumaran, 2015). Analysis of pump discharge piping has different approaches with the use of process design parameters like velocity, flow, pressure drop. Pump piping system also can be analyzed considering different piping configurations. The optimum configuration can be the one which exerts lesser force on the pump nozzle and lesser deflection in the piping (Bhave & Sonawane, 2016).

Studies related to pipe layout impact to pipe stress analysis according to study type and objective at table below

Table 3. Piping Layout Impact to Pipe Stress Analysis

Ref.	Study Type	Research Objective
Rani & Ramanathan, 2016)	Experimental	Provide adequate flexibility for absorbing thermal expansion, stresses and displacement incurred in piping system
Prachi et al., 2014	Experimental	Flexibility and stress analysis of piping system
Ravikiran et al., 2014	Experimental	Pipe stress analysis is to ensure safety against failure of the piping System by verifying structural integrity
Sarath Sankar & Senthil Kumaran, 2015	Experimental	Optimization of piping expansion loop in process plant
Buddhe, 2018	Experimental	Analysis of Pump piping based on piping configurations
Ghule & Belkar, 2250	Experimental	Stress analysis of a pump piping layout as per process piping codes
Chougule & Patil, 2017	Experimental	Optimization of piping layout for nozzle loads

Review of Vibration Impact to Pipe Stress Analysis

Every process and LNG plants operate many pumps and compressors in the processing unit. Performing the pump stress Analysis is immensely critical. The Pump's high vibration on the process plant will seriously affect the pipe and equipment's smooth operation. The resonance effect between pipe and equipment will create a severe additional desecration) (Jha et al., 2021).

The strong vibration of reciprocating pump in oil transportation station pipeline system will seriously affect the safe running of the equipment and pipeline. And the resonance between pipe and equipment will cause more severe damage. Therefore before the formal operation of station, not only static stress analysis, but also modal analysis and vibration analysis are necessary for the reciprocating pump pipeline system (X. Wu et al., 2014).

Studies related to vibration to pipe stress analysis according to study type and objective at table below

Table 4. Vibration Impact to Pipe Stress Analysis

Ref.	Study Type	Research Objective
Jha et al., 2021	Experimental	Stress analysis, modal analysis, pulsation analysis, and vibration analysis method proposed
X. Wu et al., 2014	Experimental	Static and dynamic analysis for reciprocating pump
Xu & Wang, 2020	Experimental	Vibration analysis mud piping system
Lu et al., 2016	Experimental	Vibration and stress analyses of positive displacement pump pipeline systems
Bayoumy, 2017	Experimental	Dynamic analysis for piping system due to steam hammer
Zhang et al., 2019	Experimental	Analysis of vibration fatigue for pipe fitting in aviation hydraulic system
Cao et al., 2019	Experimental	Study on vibration characteristics of fracturing piping
(W. Li et al., 2016	Experimental	Reliability analysis on high-pressure fuel pipe of diesel engine

Review of Earthquake Impact to Pipe Stress Analysis

Pipeline failure has many reasons, besides the construction and material defects, corrosion, third-party damage, design defects, misuse, geological disasters, pipeline fatigue failure and other reasons, there is an important reason is that the stress is higher than the design strength of pipeline requirements arising from the failure of damage. In the role of geological disasters, the subsidence or loss of soil will lead pipeline vacant. Pipeline vacant will lead uneven stress distribution and may cause pipeline failure (X. N. Wu, Lu, et al., 2014).

Geologic hazard such as debris flow, landslip, torrential flood and mountain earthquake and so on tends to affect the safe operation of oil and gas pipelines significantly. The changing soil support and boundary conditions will cause dynamic development of suspended length and deflection of pipeline and consequently lead to pipe failure (X. Li et al., 2014).

Studies related to earthquake to pipe stress analysis according to study type and objective at table below

Table 5. Vibration Impact to Pipe Stress Analysis

Ref.	Study Type	Research Objective
X. N. Wu, Lu, et al., 2014	Experimental	Stress analysis due to geological disaster
X. Li et al., 2014	Experimental	Analysis the stress of suspended pipelines due to geological hazard
X. Wu, Lu, Huang, et al., 2015	Experimental	Stress analysis for oil pipelines in earthquake disaster areas

Review of Cryogenic Service Impact to Pipe Stress Analysis

One method to develop offshore gas reserves is to use a floating LNG plant (FLNG) on site and export the LNG via tankers. The alternative requires the use of a reliable LNG transfer system between the FLNG and the tanker under offshore conditions. One such system involves a flexible cryogenic hose whose main body is a pipe-in-pipe hose made of two concentric corrugated 316L stainless steel pipes (C-pipe) with flanged terminations. Thermal insulation is achieved by maintaining vacuum between the inner and outer corrugated stainless steel pipes. In addition, the hose assembly contains two outer layers of helical armor wires to sustain the axial load (Srivastava et al., 2011).

The liquefied natural gas (LNG) tank outlet pipe is the weak part of any LNG vaporizing station. Due to the ultralow temperature characteristics of LNG, pipeline damage or leakage may cause major accidents. The paper used the finite element analysis method and the CAESAR II software to analyze the stresses of LNG storage tank outlet pipes and flanges in a LNG vaporizing station, the influencing factors (compensator type, compensator position, LNG density, pressure, temperature) are analyzed, and stress reduction measures are discussed) (X. Li et al., 2014).

Studies related to cryogenic service to pipe stress analysis according to study type and objective at table below

Table 6. Cryogenic Service Impact to Pipe Stress Analysis

Ref.	Study Type	Research Objective
Srivastava et al., 2011	Experimental	Stress analysis of a cryogenic corrugated pipe
Lu et al., 2018	Experimental	Stress analysis of LNG storage tank outlet piping system
Wang et al., 2022	Experimental	Stress analysis of low temperature compressor piping system in LNG

RESULTS AND DISCUSSION

Piping stress analysis of pump piping system as per process piping code B31.3 using CAESAR-II programming followed by placing of diverse pipe supports. The support type and position of the supports as per the output get from static and dynamic examination. By the software analysis of CAESAR II, the efficiency of pipe flexibility and expansion of the piping system's natural frequency is authenticating by include more oriented and load-bearing support to the elbow and Valve, which prevents the resulting of resonance successfully. The stress analysis, modal analysis, pulsation analysis, and vibration analysis method proposed in the paper will increase the lifespan and operation reliability of pipe and equipment (Jha et al., 2021).

Piping systems are complicated systems in terms of different parameters like pressure, temperature, surge, earthquake loads, wind loads etc. acting simultaneously. There two type of analysis are usually done i.e. static analysis and dynamic analysis. The static loads are due to temperature, pressure, equipment movement, weight of fluid etc. The dynamic loads are water hammer, surge, seismic waves etc. which usually create shocks (Bhave & Sonawane, 2016).

Based on the literature that has been done, expemerintal will be conducted and research related to pipe stress analysis on piping systems connected to multistage pumps with static analysis methods to determine the effect of forces due to pressure and temperature, pipe routing, pipe support and earthquake on the effect of pipe stress, and dynamic analysis to determine the effect of vibration on pipe stress. In previous research, there has been no research on pipe stress analysis on multistage pump pipes.

CONCLUSION

Based on the literature review conducted, it can be concluded that force loads are the most influential factor on stress analysis in piping systems. In addition, pipe layout and pipe support also have a significant role in influencing pipe stress analysis, which are the main elements that must be considered in piping system design. Other factors, such as earthquake, vibration, and cryogenic service, are shown to have a relatively lower influence on the stress analysis of piping, especially if the three main elements are well designed in the pipeline system. The use of Caesar II software is very effective in conducting stress analysis on piping systems.

REFERENCES

Arun, G. M. P. K., Jaya, K. I., Revanth, S. J., & Vishal, K. S. (2016). Stress Analysis of Process Piping using Caesar. IJRME - International Journal of Research in Mechanical Engineering, 24–27.

Aswin, A., & Hasnan, A. (2023). Stress Analysis Evaluation and Pipe Support Type on High-Pressure and Temperature Steam Pipe. International Journal of Mechanical Engineering Technologies and Applications, 4(1), 31–38. https://doi.org/10.21776/mechta.2023.004.01.4

Aswin, A., Wicaksono, M. B., & Wicaksana, D. A. (2024). The Effect of Bending Selection for Restrain Load Analysis Crude Oil Pipeline at Pig Launcher Area. The International Journal of Mechanical Engineering and Sciences, 8(1), 20. https://doi.org/10.12962/j25807471.v8i1.16889

Bayoumy, A. H. (2017). IMECE2015-51426. 1–15.

Bhatia, P., & Jha, A. (2014). Analytical Calculations for Piping Thickness and Stress. June.

Bhave, S. U., & Sonawane, P. (2016). Analysis of Pump Piping Based on Piping Configurations. IJIRST-International Journal for Innovative Research in Science & Technology|, 2(09), 28–34. www.ijirst.org

Bisht, S., & Dodeja, D. K. (2015). Piping Stress Analysis of a Hypothetical Oil Refinery Plant Having Separate Suction & Discharge Lines. IJSRD-International Journal for Scientific Research & Development|, 3(10), 2321–0613. www.ijsrd.com

Bisht, S., & Jahan, F. (2014). An Overview on Pipe Design using caesar II. International Journal on Emerging Technologies, 5(2), 114–118.

Buddhe, N. V. (2018). Flexibility Analysis of Extraction Piping in Duplex Heater using CAESAR II. 3(6), 329–337.

Cao, Y., Dou, Y., Huang, Y., & Cheng, J. (2019). Study on Vibration Characteristics of Fracturing Piping in Pump-Starting and Pump-Stopping Water Hammer. Journal of Failure Analysis and Prevention, 19(4), 1093–1104. https://doi.org/10.1007/s11668-019-00699-7

Cardinal, J. W., & Burnside, O. H. (2017). Stress Analysis of Buried Pipelines. 697–710.

Choudhury, B. N. (2016). Flexibility analysis of piping systems with discontinuities in displacement. American Society of Mechanical Engineers, Pressure Vessels and Piping Division (Publication) PVP, 3, 1–9. https://doi.org/10.1115/PVP2016-63066

Chougule, S., & Patil, K. (2017). Optimization of Piping System for Nozzle Loads Optimization of Piping System for Nozzle Loads. August, 0–6.

Dizdar, S., Vucina, A., Rasovic, N., & Tomovic, R. (2018). Application of pipestress and ansys in stress analysis of nuclear pipe support - Case study. IOP Conference Series: Materials Science and Engineering, 393(1). https://doi.org/10.1088/1757-899X/393/1/012021

Gengadevi, R. (2020). Validation of Piping Stresses With Caesar Ii and Fem and Comparision of Results. 1(1), 16–20.

Ghule, H. M., & Belkar, S. B. (2250). Modification in Pump Piping to Comply with Nozzle Allowable. International Journal of Emerging Technology and Advanced Engineering Website: Www.Ijetae.Com ISO Certified Journal, 9001(6).

Gu, T., Zhang, Q., Lian, Z., Yu, H., & Chen, J. (2021). Research and application of equivalent pipe model in stress analysis of lined pipe systems. International Journal of Pressure Vessels and Piping, 192(January), 104418. https://doi.org/10.1016/j.ijpvp.2021.104418

Huang, K., Wu, J., Hu, M., Xiang, H., & Zhang, Z. (2015). Optimization and Stress Analysis of Underground Oil Pipelines in High and Steep Slope Areas. The Open Civil Engineering Journal, 9(1), 477–483. https://doi.org/10.2174/1874149501509010477

Hwang, S. Y., Kim, M. S., & Lee, J. H. (2020). Thermal stress analysis of process piping system installed on lng vessel subject to hull design loads. Journal of Marine Science and Engineering, 8(11), 1–16. https://doi.org/10.3390/jmse8110926

Ilinca, C., & Vasilescu, S. (2014). A special pipe support analysis. Key Engineering Materials, 601, 80–83. https://doi.org/10.4028/www.scientific.net/KEM.601.80

Jha, A. K., Kennedy, S., & Jha, K. K. (2021). Pipe Stress Analysis of Pump System in Process Plant. IOP Conference Series: Materials Science and Engineering, 1149(1), 012004. https://doi.org/10.1088/1757-899x/1149/1/012004

Ju, X., Fang, W., Yin, H., & Jiang, Y. (2014). Stress analysis of the subsea dynamic riser baseprocess piping. Journal of Marine Science and Application, 13(3), 327–332. https://doi.org/10.1007/s11804-014-1264-8

Kim, J. S., Jang, J. H., & Kim, Y. J. (2022). Efficient elastic stress analysis method for piping system with wall-thinning and reinforcement. Nuclear Engineering and Technology, 54(2), 732–740. https://doi.org/10.1016/j.net.2021.08.026

Li, B., Li, X., Miao, Y., & Yang, H. (2020). Application of Stress Analysis Software in Oil and Gas Pipeline. IOP Conference Series: Earth and Environmental Science, 558(2). https://doi.org/10.1088/1755-1315/558/2/022006

Li, W., Zhang, J., Wang, J., & Xu, Z. (2016). Reliability analysis on high-pressure fuel pipe of diesel engine. MATEC Web of Conferences, 77, 4–7. https://doi.org/10.1051/matecconf/20167708004

Li, X., Huang, K., Lu, H. F., & Yang, W. T. (2014). Stress analysis of suspended gas pipeline. Applied Mechanics and Materials, 448–453, 1359–1362. https://doi.org/10.4028/www.scientific.net/AMM.448-453.1359

Lu, H., Huang, K., & Wu, S. (2016). Vibration and Stress Analyses of Positive Displacement Pump Pipeline Systems in Oil Transportation Stations. Journal of Pipeline Systems Engineering and Practice, 7(1), 1–11. https://doi.org/10.1061/(asce)ps.1949-1204.0000205

Lu, H., Ma, G., Li, X., & Wu, S. (2018). Stress analysis of LNG storage tank outlet pipes and flanges. Energies, 11(4), 1–19. https://doi.org/10.3390/en11040877

Mukherjee, B., Das, S., & Mazumdar, A. (2017). Stress analysis of smart support system for a steam pipeline of Sagardighi Thermal Power Plant, West Bengal, India. International Journal of Innovative and Emerging Research in Engineering, 4(1), 137–146.

Prabhu Kishore, N., & Prabhu, S. (2018). Modeling and Stress Analysis of Pump Piping. IOP Conference Series: Materials Science and Engineering, 455(1). https://doi.org/10.1088/1757-899X/455/1/012100

Prachi, M., Tambe, N., Dhande, K. K., & Jamadar, N. I. (2014). Flexibility and Stress Analysis of Piping System using CAESAR II-Case Study. Ijert, 3(6), 370–375. www.ijert.org

Raafat, E., Nassef, A., El-hadek, M., & El-Megharbel, A. (2019). Fatigue and thermal stress analysis of submerged steel pipes using ANSYS software. Ocean Engineering, 193(August), 106574. https://doi.org/10.1016/j.oceaneng.2019.106574

Rani, M. J., & Ramanathan, K. (2016). 10004702. 630004(5), 980–984.

Rao, R. N., Maiya, M., Prabhu, S., Santhosh, G., & Hebbar, G. (2021). The analysis of a piping system for improvement of a system in a process unit. Materials Today: Proceedings, 46(xxxx), 2791–2797. https://doi.org/10.1016/j.matpr.2021.02.595

Ravikiran, N., Reddy, V. S., & Kumar, K. G. (2014). 3D Modeling and Stress Analysis of Flare Piping. International Journal of Engineering Trends and Technology, 16(3), 103–108. http://www.ijettjournal.org

Sarath Sankar, K. S., & Senthil Kumaran, S. (2015). Optimization of piping expansion loop in process plant. International Journal of Applied Engineering Research, 10(49), 574–578.

Sharma Ȧ, P., Tiwari Ȧ, M., & Sharma Ȧ Ȧ, K. (2014). Design and Analysis of a Process Plant Piping System. 31–39. http://inpressco.com/category/ijcet

Sohail, M., Venukumar, S., & Reddy, M. V. (2017). An outline of piping design using CAESER II - Case Study. Materials Today: Proceedings, 4(8), 8269–8278. https://doi.org/10.1016/j.matpr.2017.07.169

Srivastava, V., Buitrago, J., & Slocum, S. T. (2011). Stress analysis of a cryogenic corrugated pipe. Proceedings of the International Conference on Offshore Mechanics and Arctic Engineering - OMAE, 3, 411–421. https://doi.org/10.1115/OMAE2011-49852

Verma, A. K., Yadav, B. K., Gandhi, A., Kumar, E. R., Thorve, S., & Soni, R. S. (2018). Pipe stress analysis of first wall helium cooling system for conceptual design development of IN LLCB TBM. Fusion Engineering and Design, 137(July), 130–136. https://doi.org/10.1016/j.fusengdes.2018.09.002

Verma, A. K., Yadav, B. K., Gandhi, A., Saraswat, A., Verma, S., & Kumar, E. R. (2019). 3D modelling of loop layout, pipe stress analysis and structural responses of high-pressure high-temperature experimental helium cooling loop (EHCL). Fusion Engineering and Design, 145(April), 87–93. https://doi.org/10.1016/j.fusengdes.2019.05.015

Wang, B., Zhang, Z., Huang, K., Zhang, Y., Zhang, Z., Gao, H., & Fu, L. (2022). Stress and Pressure Pulsation Analysis of Low Temperature Compressor Piping System in LNG Vaporizing Station. Energies, 15(5). https://doi.org/10.3390/en15051874

Wu, X., Lu, H., Huang, K., Wu, S., & Qiao, W. (2015). Frequency spectrum method-based stress analysis for oil pipelines in earthquake disaster areas. PLoS ONE, 10(2), 1–24. https://doi.org/10.1371/journal.pone.0115299

Wu, X., Lu, H., & Wu, S. (2015). Stress analysis of parallel oil and gas steel pipelines in inclined tunnels. SpringerPlus, 4(1), 1–25. https://doi.org/10.1186/s40064-015-1453-1

Wu, X., Lu, H., Wu, S., Huang, K., Wan, J., Li, W., & Liu, Z. (2014). Stress analysis of reciprocating pump pipeline system in oil station. Journal of Chemical and Pharmaceutical Research, 6(7), 2026–2032.

Wu, X. N., Lu, H. F., Wu, S. J., Kun, H., Chen, X., Kang, F. X., & Liu, Z. L. (2014). Analysis of suspended pipeline stress sensitivity. Applied Mechanics and Materials, 501–504, 2331–2334. https://doi.org/10.4028/www.scientific.net/AMM.501-504.2331

Wu, X. N., Wu, S. J., Lu, H. F., Jie, W., Liu, J. L., Li, W. T., & Liu, Z. L. (2014). Analysis of Hot Oil Pipeline Stress Influencing Factors. Advanced Materials Research, 887–888, 899–902. https://doi.org/10.4028/www.scientific.net/AMR.887-888.899

Xu, H. M., & Wang, B. (2020). Vibration analysis of high pressure mud piping systems and vibration reduction method. Proceedings - 2020 3rd World Conference on Mechanical Engineering and Intelligent Manufacturing, WCMEIM 2020, 60, 732–737. https://doi.org/10.1109/WCMEIM52463.2020.00157

Ye, C., Nenghong, Z., Rui, Y., Fengbing, X., Tao, L., Renjie, H., & Lijun, C. (2023). Stress Analysis of Large Diameter Pipe Interface Structure of Boiler Main Steam Pipe. Journal of Energy and Natural Resources, 12(1), 1–6. https://doi.org/10.11648/j.jenr.20231201.11

Zahid, U., Khan, S. Z., Khan, M. A., Bukhari, H. J., Ahmed, I., & Khan, K. A. (2018). A methodology for flexibility analysis of process piping. Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering, 232(6), 751–761. https://doi.org/10.1177/0954408917738963

Zhang, F., Yuan, Z., Zhang, F., & Liang, N. (2019). The analysis and estimation of vibration fatigue for pipe fitting in aviation hydraulic system. Engineering Failure Analysis, 105(July), 837–855. https://doi.org/10.1016/j.engfailanal.2019.07.038