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Dimensional check of weld neck flange based on ASME B16.5

Fatima Sari Ritonga[1], Adi Syahputra Purba[2], Jefri Kemri Rodi Samuel Simanjuntak[3], Nurul Fadilah[4], Mutia Amalia[5]

[1,5]Welding Engineering and Fabrication Technology, Mechanical Engineering, Politeknik Negeri Medan, Indonesia
[2,3,4]Mechanical Engineering, Politeknik Negeri Batam, Indonesia

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ABSTRACT

This study aims to verify that the dimensions of a weld neck flange conform to ASME B16.5 standards. The flange used is a raised face type made of carbon steel ASTM A105N with 16-inch NPS, selected for its corrosion resistance, and welded with UNS 006625, a nickel-rich alloy that enhances corrosion protection. Dimensional checks were performed on five samples, each measured three times, using both visual inspection and measuring tools, including a roughness comparator and vernier caliper. Key dimensions measured include outside diameter (705 mm, tolerance +4 mm/-1 mm), inside diameter (333.3 mm, ±1.5 mm), bolt circle diameter (616 mm, ±1.5 mm), flange thickness (88.90 mm, +3 mm), and hub thickness (30.43 mm post-welding, with tolerance not less than 12.5% of pipe wall thickness) the visual inspection assessed surface roughness within the acceptable range of 3.2 µm to 6.3 µm. The inspection results showed that all measured dimensions were within the permissible limits, confirming that the weld neck flange meets the requirements of ASME B16.5.

Corresponding Author:

Adi Syahputra Purba,
Mechanical Engineering,
Politeknik Negeri Batam,
Jl. Ahmad Yani, Batam Centre, Batam, 29461, Indonesia
Email: adipurba@polibatam.ac.id

1. INTRODUCTION

In the oil and gas industry, the extraction process from beneath the earth's surface requires a piping system to transport crude oil from underground to storage facilities (Chittumuri et al., 2025; Reza Rahman, 2015). The pipes are linked together using flanges, which serve as a mechanical connector that joins two sections of pipe into a single pipeline system, secured with bolts (Coria et al., 2018; Sharma, 2023). There are several types of flanges, including lap joint, slip-on, socket weld, threaded, blind, and weld neck (Modi et al., 2018; Si et al., 2024). Weld neck flanges are widely used because they can handle extreme temperature variations, endure both low and high pressures, and are relatively easy to install (Dai et al., 2023). This type of flange includes a long, tapered hub that helps distribute mechanical stress away from the flange toward the pipe, reducing the risk of flow disturbance (Hanyang & Qubao, 2018). The connection between the pipes is made through the hub, which is welded directly to the pipes (Sabry et al., 2022). The face of the flange serves as the sealing interface between the pipes, then the flanges are bolted together to ensure a leak proof connection (Alias, J., Alang, N.A., Ahmad, 2023; Elkhlaidy et al., 2023) to minimize the risk of face distortion due to internal fluid pressure. This assembly method minimizes the risk of face distortion due to internal fluid pressure (Baiyan et al., 2023; Bei et al., 2024). Pipe flanges are selected according to the pressure-temperature rating and pipe class, in compliance with EN 1092-1 (Elkhlaidy et al., 2023), ASME B16.5, ASME B16.47 standards (Sharma, 2023).

Many oil and gas mines have flanges that have been in place for a long time and the flange's appearance significantly changes after prolonged exposure to moisture from environments and field operating conditions, such as temperature fluctuations, pressure cycling, fluid flow velocity, chemical composition of the medium (e.g., high chloride content, low pH, or acidic compounds) (Hakimian, S, Bouzid, A, & Hof, 2024). These factors significantly influence corrosion mechanisms, such as pitting corrosion, crevice corrosion, and erosion-corrosion, which can accelerate dimensional degradation beyond the tolerances.

Corrosion may then lead to material peeling on the flange surface. This results in deviations of the flange dimensions from their actual size and also causes changes in the flange surface texture (Chu et al., 2024). It will cause other problems to the piping system, such as leaking on the piping and the flange (Pronk, 2022; Stikvoort, 2021), therefore this area is enhanced with corrosion-resistant elements such as nickel (Tayactac & Ang, 2022), that is known for its corrosion resistance (Bassford & Hosier, 2002). Due to its corrosion resistance, PT Cladtek Bi-Metal Manufacturing then coated the hub and face areas using CRA (Corrosion Resistant Alloy). This CRA is applied through welding using the GTAW method and UNS N06625 wire, which contains a high nickel content. This addition helps slow down the corrosion rate on the weld neck flange (Sianturi & Sianturi, 2023). Inspection of the welding results revealed that several flanges were defective, including undersized inner diameters (ID), excessive surface roughness after machining, and some instances of pipe leakage. Therefore, dimensional reinspection and measurement will be conducted following the ASME B16.5 standard.

However, the coverage does not comprehensively address variations in this study aims to ensure that the dimensions of the weld neck flange in PT.Cladtek Bi-Metal Manufacturing comply with the standards set by ASME B16.5. The research used ASTM A105N material, a forged carbon steel weld neck flange with a raised face type and NPS 16". Visual inspection includes surface roughness assessment using a roughness comparator, and dimensional measurements are taken using a vernier calliper, including outside diameter, inner diameter, bolt centre diameter, flange thickness, and hub thickness. The scope of this research is limited to the dimensional inspection method for weld neck flanges, which is helpful in determining the effectiveness, accuracy, and productivity during the dimension verification process to ensure compliance with specified standards and to meet customer specification variations.

2. RESEARCH METHOD

Collecting Data Method

This type of research is part of qualitative research, with data collection methods employed through several approaches. First, field observation was conducted by collecting data from PT. Cladtek Bi-Metal Manufacturing on February 28, 2022. Inspection of the welding results revealed that several flanges were defective, including undersized inner diameters (ID), excessive surface roughness after machining, and some instances of pipe leakage.

Second, a literature review was undertaken to gain theoretical insights into the standards of the flange and piping system. Third, the dimensional inspection of the piping system was conducted to make sure the weld neck flange following the ASME B16.5 standard. The reaserch flowchart shown in figure 1, illustrates the steps involved in outlining the stages of this research.

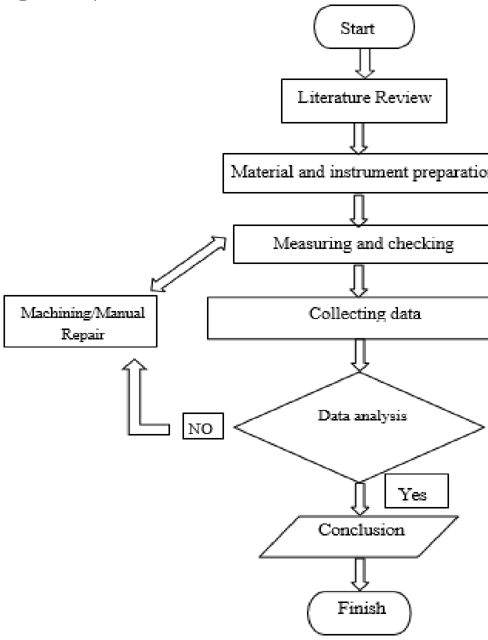

Figure 1. Flow Chart

Materials and Equipment

Before conducting measurements, the calibration dates of the measuring instruments were verified to ensure that the data obtained were valid and reliable. The class used for the material to be tested is class 900. The measuring instruments used include a 1000 mm vernier caliper with an accuracy of 0.05 mm, a 600 mm vernier caliper with the same accuracy, and a roughness comparator for evaluating the surface roughness of the material. All instruments were confirmed to be in proper working condition and had been calibrated according to applicable standards. The assembly method for flange, illustrated in the figure 2.

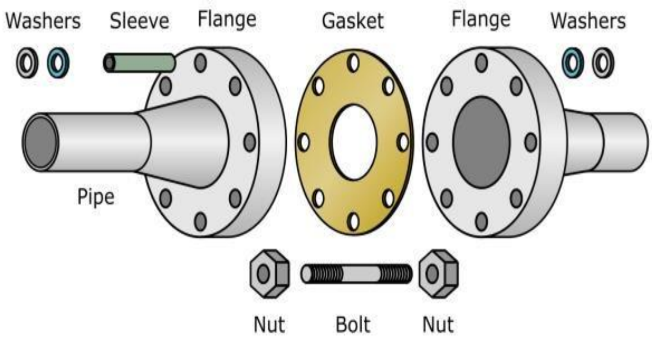

Figure 2. Effects of selecting different switching under dynamic condition (*Flange*, n.d.)

The material used in this study is ASTM A105N with a raised face type as shown in figure 3. The weld neck flange tested in this study is made from ASTM A105N material, with the following specifications: it is made from ASTM A105N forged carbon steel, which is suitable for both room-temperature and high-temperature applications. N (normalizing) addition indicates that the material has undergone a normalizing heat treatment process, in which the component is heated to a high temperature and then cooled naturally to ambient temperature. This treatment enhances the material's toughness, which is further verified through impact testing and Charpy V-Notch (CVN) testing. As a result, ASTM A105N is classified as a material with high toughness.

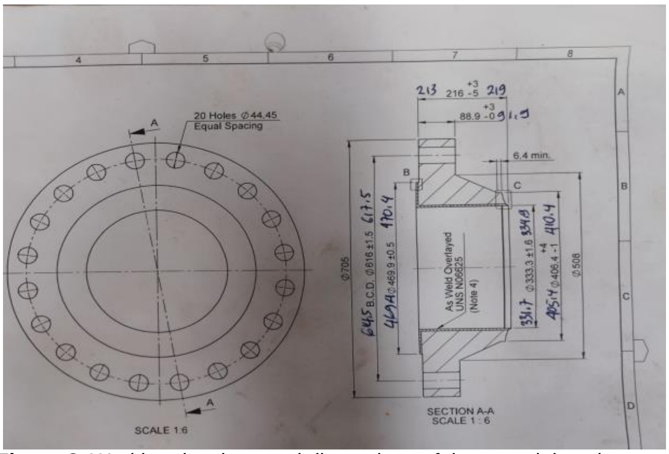

Figure 3. Working drawings and dimensions of the materials to be used

Visual Checking and Flange Dimension Measurement

The measurement involved comparing the flange face with a roughness comparator to ensure there were no defects resulting from welding or grinding during the post-welding cleaning process. Five flange samples were examined to evaluate whether the surface finish complied with the requirements specified by ASME B16.5. The inspection was performed on all flange areas to detect any irregularities. Additionally, dimensional measurements of the flange were carried out using precision instruments. The outside diameter was measured using a 1000 mm vernier caliper at the outermost edge of the flange. The inside diameter, specifically at the hub, was measured with a 600 mm vernier caliper. The bolt circle diameter, which is the distance between bolt holes, was also measured using a 1000 mm vernier caliper. For the flange thickness, measurements were taken on the outer flange surface using a 600 mm vernier caliper. The hub thickness was measured at the outermost part of the hub using the same tool. These measurements ensured the flange met dimensional specifications and conformed to relevant standards.

3. RESULTS AND DISCUSSIONS

This section on data analysis and discussion presents the results obtained from inspecting and measuring the flange. It includes visual inspection focusing on surface roughness, as well as dimensional measurements such as outside diameter, inside diameter, bolt circle diameter, flange thickness, and hub thickness.

Surface Roughness

Figure 4 shows the visual inspection of surface roughness on the raised face area using a roughness comparator, five flange samples were examined to evaluate whether the surface finish complied with the requirements specified by ASME B16.5. All five samples fell within the tolerance range specified by ASME B16.5, which is 3.2 µm – 6.3 µm, with a groove range per inch of 46 to 56 grooves, or approximately 1.8 to 2.2 grooves per millimeter. The inspection confirmed that all five samples met these criteria, indicating that the machining process produced a consistent and acceptable surface finish. This ensures proper gasket seating and sealing performance, which is critical in preventing leakage in flange connections. The consistency across all samples also suggests effective control of post-welding grinding and machining processes (Engineers, 2020; Haruyama et al., 2013).

Figure 4. Raise face flange surface roughness measurement

Diameter and Thickness Measurement

This section presents the measurement results of the main dimensions of the neck flange component, including outside diameter, inside diameter, bolt circle diameter, flange thickness, and hub thickness. Measurements were conducted on five samples, with three repetitions for each parameter, to obtain representative average values. All measurements were compared with the tolerance limits specified in the ASME B16.5 standard for NPS 16" sizes. 1. Class pada flange menandakan tingkat pressure dan temperature yang bisa diterima oleh flange ASME B16.5 (Bouzid et al., 2024). The classes available for flanges range from 150, 300, 400, 600, 900, 1500, to 2500.

Table 1. Diameter measurement data

Sample No.	*Outside Diameter* (Size. 705mm) Toleransi : +4mm,-1mm				*Inner Diameter* (Size. 333.3 mm) Toleransi : ±1.5 mm				*Bolt Diameter Circle* (Size : 616 mm) Toleransi : ±1.5 mm			
	Data Sample (mm)			Rata- rata	Data Sample (mm)			Rata- rata	Data Sample (mm)			Rata- rata
Sample 1	705.50	704.40	704.80	704.90	332.10	332.00	332.00	332.03	616.00	616.00	615.80	615.93
Sample 2	704.40	704.10	704.40	704.30	332.70	332.00	332.30	332.33	616.00	616.00	616.00	616.00
Sample 3	705.00	705.00	705.00	705.00	331.70	331.90	331.90	331.83	616.00	615.00	615.00	615.33
Sample 4	704.60	704.80	705.00	704.80	332.00	333.00	332.50	332.50	615.60	615.50	616.00	615.70
Sample 5	704.00	704.00	704.50	704.16	332.30	332.50	333.20	332.33	615.00	616.00	616.00	615.67

For the outside diameter, inside diameter, and bolt circle diameter, repeated measurements were conducted, three times for each of the five samples. According to ASME B16.5, the specified size for the outside diameter of NPS 16" is 705 mm, with a tolerance of +4 mm / -1 mm, resulting in an acceptable range of 704 mm to 709 mm. Based on the data in Table 1, the lowest average recorded was 704.16 mm, and the highest was 705 mm. For the inside diameter, ASME B16.5 specifies 333.3 mm for NPS 16" with a tolerance of ±1.5 mm, resulting in a range of 331.8 mm to 334.8 mm. The data in Table 1 shows the lowest average at 331.83 mm and the highest at 332.50 mm. The bolt circle diameter for NPS 16" is 616 mm with a tolerance of ±1.5 mm, giving a permissible range of 614.5 mm to 617.5 mm. The measurement results show the lowest average at 615.33 mm and the highest at 616 mm. Therefore, the measurements for outside diameter, inside diameter, and bolt circle diameter all fall within the tolerance ranges specified by ASME B16.5.

Table 2. Thickness measurement data

Sample No.	*Flange Thickness (Size : 88.90 mm) Toleransi : +3 mm*				*Hub Thickness*			
	Data Sample (mm)			Rata- rata	Data Sample (mm)			Rata- rata
Sample 1	91.70	90.60	90.20	90.83	37.20	36.60	37.20	37.00
Sample 2	91.30	91.00	91.00	91.10	36.40	37.20	37.00	36.87
Sample 3	91.20	91.00	91.00	91.07	37.20	37.00	37.00	37.07
Sample 4	91.70	91.20	91.90	91.60	37.20	37.70	37.00	37.30
Sample 5	91.90	90.80	91.00	91.23	37.00	37.00	36.60	36.87

Table 2 presents measurement data for bolt circle diameter and flange thickness. The data was obtained by taking five samples with three repeated measurements. For NPS 16", the flange thickness is specified as 88.90 mm with a tolerance of +3 mm, resulting in a maximum allowable value of 91.90 mm. The measurement results show an average range from the lowest at 90.83 mm to the highest at 91.60 mm. This indicates that the machining and finishing processes for the flange thickness were well-maintained and did not exceed the permissible material allowance, which is critical for ensuring flange strength under pressure (Sabry et al., 2024). The customer's requirement for hub thickness specifies a minimum carbon steel wall thickness of 27.09 mm before welding, and a post-welding size of 30.43 mm. There is also a tolerance condition that the thickness must not be less than 87.5% of the nominal pipe thickness or 12.5% of the pipe wall thickness. Based on the tests conducted, the hub thickness measurements show an average range from 36.87 mm to 37.30 mm. Both sets of measurements fall within the tolerance limits specified by ASME B16.5. The closeness of the OD and ID values to the lower tolerance limits has technical implications for flange service life. If these tolerances continue to drift downward due to uncontrolled machining processes, the risk of leakage or installation failure will increase. Therefore, quality control in the manufacturing process is critical to maintaining dimensional consistency within tight tolerances.

In practical terms, these results demonstrate that the manufacturing process applied can consistently produce flanges with high precision, meeting ASME B16.5 requirements for both dimensional parameters and surface finish. This supports the reliable operation of high-pressure piping systems without disruptions, while minimising downtime due to leakage or component replacement. These findings underscore the importance of strengthening quality control in flange manufacturing. While the tested samples met ASME B16.5 tolerances, past occurrences of undersized inner diameters, excessive surface roughness, and leakage reveal potential process inconsistencies. Implementing in-line inspections, precision metrology tools such as CMM.

4. CONCLUSION

Based on the results of visual inspection and dimensional measurements, it can be concluded that the weld neck flanges tested in this study meet the tolerance requirements specified by ASME B16.5. The visual inspection of surface roughness on the raised face areas fell within the allowable range of 3.2 µm to 6.3 µm. Dimensional measurements, including outside diameter, inside diameter, and bolt circle diameter, were performed on five samples with three repetitions each. All values obtained were within the permissible tolerances, with the outside diameter ranging from 704.16 mm to 705.00 mm (tolerance: 704 mm–709 mm), inside diameter from 331.83 mm to 332.50 mm (tolerance: 331.8 mm–334.8 mm), and bolt circle diameter from 615.33 mm to 616 mm (tolerance: 614.5 mm–617.5 mm). The flange thickness, ranging from 90.83 mm to 91.60 mm, complied with the maximum limit of 91.90 mm. The hub thickness, measured after welding, ranged from 36.87 mm to 37.30 mm, exceeding the minimum requirement of 87.5% of the nominal pipe wall thickness (30.43 mm). Overall, the measurment shows that both the visual and dimensional characteristics of the tested flanges are following ASME B16.5 standards, confirming the quality and compliance of the components evaluated.

The study is limited by its small sample size, single-source manufacturer, and focus on a specific size and pressure class. The scope was restricted to visual and dimensional conformity, without assessment of operational performance under pressure and temperature variations. Furthermore, the tests were conducted in a controlled environment, which may not fully reflect field conditions. Future research should expand the sample pool to include different manufacturers, sizes, and pressure classes as well as the application of advanced metrology tools such as 3D scanning, coordinate measuring machines (CMM), or laser profilometry, are recommended to enhance measurement accuracy and broaden the understanding of dimensional stability and surface integrity over the service life.

REFERENCES

Alias, J., Alang, N.A., Ahmad, A. H. (2023). Failure Analysis of a Carbon Steel Pipe-Flange Component. *J Fail. Anal. and Preven*, *23*, 490–496. https://doi.org/https://doi.org/10.1007/s11668-022-01572-w

Baiyan, H., Biaobiao, J., Qihang, W., Rui, N., & Jiankun, Y. (2023). Strength and tightness evaluation method for pipe flange connections considering thermal effects. *Journal of Loss Prevention in the Process Industries*, *83*. https://doi.org/https://doi.org/10.1016/j.jlp.2023.105053

Bassford, T. H., & Hosier, J. (2002). Handbook of Materials Selection. In K. Myer (Ed.), *Handbook of Materials Selection*. https://doi.org/10.1002/978047017255

Bei, G., Xu, X., Ma, C., Sun, J., Zhang, Y., & Yu, Q. (2024). Reliability Evaluation of a Dynamic-Pressure Mechanical Seal Based on Liquid Film Vaporization Phase Transition. *Coatings*, *14*(2). https://doi.org/10.3390/coatings14020233

Bouzid, A., Bouzid, S., & Benfriha, K. (2024). On the Strength and Tightness of ASME B16.5 and B16.47 Series A Standard Flanges. *Journal of Pressure Vessel Technology*, *146*(1). https://doi.org/https://doi.org/10.1115/1.4063890

Chittumuri, I., Alshehab, N., Voss, R. J., Douglass, L. L., Kamrava, S., Fan, Y., Miskimins, J., Fleckenstein, W., Wheeler, S., & Bandyopadhyay, S. (2025). Risk Analysis of Flowlines in the Oil and Gas Sector: A Geographic Information Systems and Machine Learning Approach. *SPE Journal*, 1–12. https://doi.org/10.2118/228286-pa

Chu, C. H., Chen, Y. R., & Chen, S. M. (2024). Identification of flange specification in real industrial settings with human reasoning assisted by augmented reality. *Advanced Engineering Informatics*, *62*(May). https://doi.org/10.1016/j.aei.2024.102882

Coria, I., Martín, I., Bouzid, A. H., Heras, I., & Abasolo, M. (2018). Efficient assembly of bolted joints under external loads using numerical FEM. *International Journal of Mechanical Sciences*, *142–143*, 575–582. https://doi.org/10.1016/j.ijmecsci.2018.05.022

Dai, K., Du, H., Luo, Y., Han, R., & Li, J. (2023). Stress Distribution Prediction of Circular Hollow Section Tube in Flexible High-Neck Flange Joints Based on the Hybrid Machine Learning Model. *Materials*, *16*(20). https://doi.org/10.3390/ma16206815

Elkhlaidy, M., Carnicero, A., & Perera, R. (2023). Influence of flange geometric configuration and bolt stress on joint integrity during assembly using FEA. *International Journal of Pressure Vessels and Piping*, *202*, 104912. https://doi.org/10.1016/J.IJPVP.2023.104912

Engineers, A. S. of M. (2020). *American Society of Mechanical Engineers*. ASME B16.5-2020: Pipe Flanges and Flanged Fittings—NPS ½ Through NPS 24 Metric/Inch Standard. https://www.passeidireto.com/arquivo/112371490/asme-b-16-5-2020

Flange. (n.d.). https://savree.com/en/encyclopedia/flange-assembly

Hakimian, S, Bouzid, A, & Hof, L. (2024). Effect of Temperature on the Crevice Corrosion Propagation on Flange Faces. *Proceedings of the ASME 2024 Pressure Vessels & Piping Conference*. https://doi.org/https://doi.org/10.1115/PVP2024-124104

Hanyang, L., & Qubao. (2018). GMAW welding process training for high neck flange of thin-walled tube of transmission tower. *MATEC Web of Conferences*, *175*, 1–5. https://doi.org/10.1051/matecconf/201817503008

Haruyama, S., Nurhadiyanto, D., Choiron, M. A., & Kaminishi, K. (2013). Influence of surface roughness on leakage of new metal gasket. *International Journal of Pressure Vessels and Piping*, *111–112*(November 2017), 146–154. https://doi.org/10.1016/j.ijpvp.2013.06.004

Modi, A., Modi, S., Prajapati, R., & Shukla, V. (2018). *Design & Coding of Weld Neck Flange for Shell and Tube Heat Exchanger*. *6*(2), 2102–2110.

Pronk, D. (2022). *Corrosion and corrosion protection for flange connections in pipelines*. https://valve-world.net/wp-content/uploads/sites/21/2022/03/Corrosion-and-corrosion-protection-for-flange-connections-in-pipelines.pdf

Reza Rahman, M. (2015). Perencanaan Modifikasi Pipa Penyalur Minyak Dengan Adanya Penambahan Platform Produksi. *Seminar Nasional Cendekiawan*, 285–291.

Sabry, I., D. T. Thekkuden, A., H. I., M., & Abdullah, K. (2022). Variants of friction stir welding for joining AA 6063 pipes. *Advances in Science and Engineering Technology International Conferences (ASET)*, 1–4. https://doi.org/10.1109/ASET53988.2022.9735118

Sabry, I., Hewidy, A. M., Alkhedher, M., & Mourad, A. H. I. (2024). Analysis of variance and grey relational analysis application methods for the selection and optimization problem in 6061-T6 flange friction stir welding process parameters. *International Journal of Lightweight Materials and Manufacture*, *7*(6), 773–792. https://doi.org/10.1016/j.ijlmm.2024.06.006

Sharma, H. K. (2023). A Study On Manufacturing Of Flange Joint Used In Transportation Vehicle. *International Journal of Innovations In Science Engineering And Management*, *2*(1), 1–5.

Si, J., Liu, W., Zhu, L., Zhu, Y., Zhao, G., Hong, J., & Zhang, C. (2024). Experimental Study on Mechanic Behavior of Flange Joint for Steel Tube Under Axial Tension. *Buildings*, *14*(8). https://doi.org/https://doi.org/10.3390/buildings14082282

Sianturi, R., & Sianturi, R. L. (2023). Analisis Lanjutan Distribusi Tegangan Sisa dan Keausan Pahat Milling pada Pemesinan Keras. *Jurnal Kolaborasi Sains Dan Ilmu Terapan*, *1*(2), 37–42. https://doi.org/10.69688/juksit.v1i2.10

Stikvoort, W. (2021). Approaches for assessing exerted piping loads on flanged joints. *Quest Journals Journal of Research in Mechanical Engineering*, *7*(11), 1–6. www.questjournals.org

Tayactac, R. G., & Ang, E. B. O. (2022). Assessment of Corrosion Resistant Alloy (Cra) Clad Material for Geothermal Wellhead Piping System. *ASEAN Engineering Journal*, *12*(1), 207–219. https://doi.org/10.11113/aej.v12.16773