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Design Analysis of The Strength of Straight (Vertical) Pipe Connections Using Modified Flanges in Deep Well Pump Pipe Installations

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Abstract-- *Strength Analysis of Straight (Vertical) Pipe Connections Using Modified Flange on Deep Well Pump Pipe Installation is an important part of the oil and natural gas industry, because it functions to drain fluid from the well to the oil gathering station. Well pump pipelines must be well designed to ensure safety and operational efficiency. One of the important components in the well pump pipeline design is the straight (vertical) pipe connection using a modified flange. The strength analysis of this straight pipe connection is carried out to determine how the modified flange affects the strength of the pipe connection. The method used is a design analysis of the strength of straight pipe joints using modified flanges with reference to international codes and simulations using Solidworks software. The results show that the flange must be modified because it is for the cable line and adjusts to the diameter of the well which is 8' in diameter. The strength of straight pipe joints is also affected by pipe diameter, operating pressure, and pipe material type. The conclusion of this analysis is that the modified flange can reduce the strength of the straight pipe connection, so it requires proper consideration and calculation. Therefore, the modified flange should be considered in the well pump pipeline design to ensure safety and operational efficiency.*

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1. INTRODUCTION

Strength analysis of straight (vertical) pipe connections using modified flanges in deep well pump pipe installations is a very important research in improving the safety and efficiency of piping systems. The well pump piping system is a critical component in the mining and water treatment industries, because it acts as a link between the well pump and other equipment used to drain fluids.

Straight pipe joints using flanges are one of the most common types of joints used in piping systems. However, these joints are subject to significant stress due to static, dynamic and thermal loads, which can lead to structural failure and consequently damage to the piping system. Therefore, it is necessary to analyze the strength of straight pipe joints to ensure that they can withstand the applied loads without being damaged.

Flange modification is one solution to make the path of pump cables to the ground surface. However, careful analysis is needed to determine the optimal flange modification parameters.

This study aims to analyze the strength of straight pipe joints using modified flanges in deep well pump pipe installations. This analysis will involve the use of the finite element method to model the pipe joints and determine the stresses that occur in the joints. In addition, the research will also consider applicable standards and codes, such as ASME B31.1, to ensure that the design of straight pipe joints with modified flanges meets safety requirements.

In this research, the necessary data and information will be obtained through direct observation of the deep well pump pipe installation, as well as analysis of existing data. The results of this research will be presented in the form of a detailed report, including the results of stress calculations, deformation, and strength analysis of straight pipe joints using a modified flange.

Thus, this research is expected to provide an effective and efficient solution for the calculation of the strength of straight pipe joints in deep well pump pipeline installations, so as to ensure that the piping system can operate safely and efficiently .

2. METHODOLOGY

2.1 Data Collection
Data collection was obtained when conducting observations at Pertamina Lawe - Lawe Project, East Kalimantan. The data that will be obtained in this study uses the following stages:

2.2 Observation
Make direct observations on the layout of the existing piping system. Researchers made structured observations in accordance with the design of the oil piping system..

2.3 Structured Interviews
This stage is carried out by interviewing one of the engineers in the field, about the data needed to analyze the stress of the piping system.

2.4. Standards and Codes Used
In this study, the analysis carried out refers to the codes and standards that have been set, namely the ASME B 31.3 2018 Process Piping standard, ASME B16.5-2020 Pipe Flanges Flanged Fittings, ASME B36.19 2022, Welded and Seamless Wrought Stainless,ASME_B36_10_2022_Welded_and_Seamless Steel Pipe which these standards regulate the Process Plant in a company. Based on the above standards, for the permissible stress value, a comparison is made with the stress value obtained from the analysis results which is influenced by the load on the pipe. This comparison is used to fulfill the conditions $SL < Sh$ (sustain load) and $SE < SA$ (expansion load) from the value of the stress results obtained, so that in this code standard it can be done in the form of software calculations and manual calculations according to the data obtained in the data collection in the company can be calculated by manual calculation using the equation.

2.5 Design
a. **Minimum Pipe Thickness**
Based on ASME B31.3, 2018 para 304.1.2 the straight pipe thickness formula is:

t = PD/(2(SEW+PY)) (1)

b. **Minimum Schedule Pipa**
Based on ASME B31.3, 2018 the straight pipe schedule formula is:

Shedule Number = (P/S) x 1000 (2)

c. **Selection of Flange Class used Flange Class Calculation**
Refer to ASME 16.5 Material Group for ASTM materials as shown in the figure below.

	Working Pressures by Classes, psig						
	Class						
Temp., °F	150	300	400	600	900	1500	2500
−20 to 100	285	740	985	1,480	2,220	3,705	6,170
200	260	680	905	1,360	2,035	3,395	5,655
300	230	655	870	1,310	1,965	3,270	5,450
400	200	635	845	1,265	1,900	3,170	5,280
500	170	605	805	1,205	1,810	3,015	5,025
600	140	570	755	1,135	1,705	2,840	4,730
650	125	550	730	1,100	1,650	2,745	4,575
700	110	530	710	1,060	1,590	2,655	4,425
750	95	505	675	1,015	1,520	2,535	4,230
800	80	410	550	825	1,235	2,055	3,430
850	65	320	425	640	955	1,595	2,655
900	50	230	305	460	690	1,150	1,915
950	35	135	185	275	410	685	1,145
1,000	20	85	115	170	255	430	715

Figure 1. Material group (ASME 16.5)

d. Flange Stress Calculation
To calculate stress, the formula used is:

σt = Friserpipe /A3” flange (3)

where:
σt = Flange stress (N/mm2)
F = Normal Force (N)
A = Flange Area (mm2)

e. Sketch Drawing
Here are the preparatory steps that I consider before starting to sketch piping drawings:

- Understanding the Project Specifications, understanding the type of fluid to be conveyed, the operational pressure and temperature, and any other restrictions or special requirements that may apply.
- Selection of Software, which I will use to sketch the piping drawings is AutoCAD.
- Layout Planning, determining the position of main pipes, branches, fittings, and other components.
- Selection of ASME Piping Standard, according to the needs of the project, I refer to ASME for the chemical and oil industry.
- Material Selection, determine the pipe material to be used based on the operational environment, temperature, pressure, and chemical properties of the fluid being flowed. ensure choosing materials that comply with ASME.
- Analysis
- Flange strength analysis of pipes based on ASME and Finite Element Method is a process to ensure that the flange in the piping system can withstand mechanical loads and internal pressure in accordance with established standards.

3. RESULT AND DISCUSSION

3.1 Using International References (ASME)

a. Pipe Thickness
Pipe thickness is determined by the following formula.

Tm = 8/7 ((p x D)/(2(SE+PY))) + c (4)
Tm = 8/7 ((471.372 x 2)/(2(19900x1+471372x0.4))) + 0.125
Tm = 0.169 In ~ 4.292 mm

b. Minimum Schedule Number of Pipe

Schedule Number = 1000 x (471.372/19900)
Schedule Number = 23.687

c. Class of Flange
Using ASTM A105 grade 300, with a tolerance pressure of 740 psig

d. Strength of Flange
Manual calculation obtained:

σt = Friser pipa /A 3’’ flange (5)

= 88190.396 / (πr 2 – (πr 2 + (w x l))
= 88190.396 / (π82.52 – ((π452)+ (w x l) + (7 x π x 9.52))
= 88190.396 / (21371.625 – (6358.5 + 1400 + 1983.695))
= 88190.396 / (21371.625 – 9742.195)
= 88190.396 / 11629.43
= 7.583 N/mm2

Based on ASME B31.3 Book, Allowable Stress for ASTM A105 2” Flange (at Temp < 65 Celsius Degrees) = 22.5 ksi = 155.132 N/mm2
Conclusion = actual stress due to normal force (7.583 N/mm2) < allowable tensile stress (155.132 N/mm2) (satisfactory)

3.2 Using FEA (solidworks)
The results are as shown in Figure 2 below.

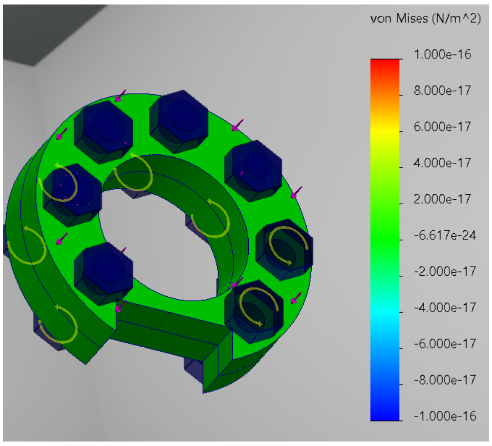

Figure 2. FEA Results

Based on the above analysis with a load of 9 tons (based on the total load on the riser pipe below ground level) it can be concluded that:

- Maximum Stress is 132,952 MPa (maximum stress from 9 tons simulation load) with a minimum limit of allowable stress of 248,168 MPa. The largest stress value occurs in the bolt.
- The minimum Factor of Safety is 1.867 (the point that experiences the heaviest load).
- Maximum stress (132.952 Mpa) < Permitted stress (248.168 Mpa) OK status

3.3 Sketch Drawing
The following (figure 3) is a drawing of the piping installation at the wells.

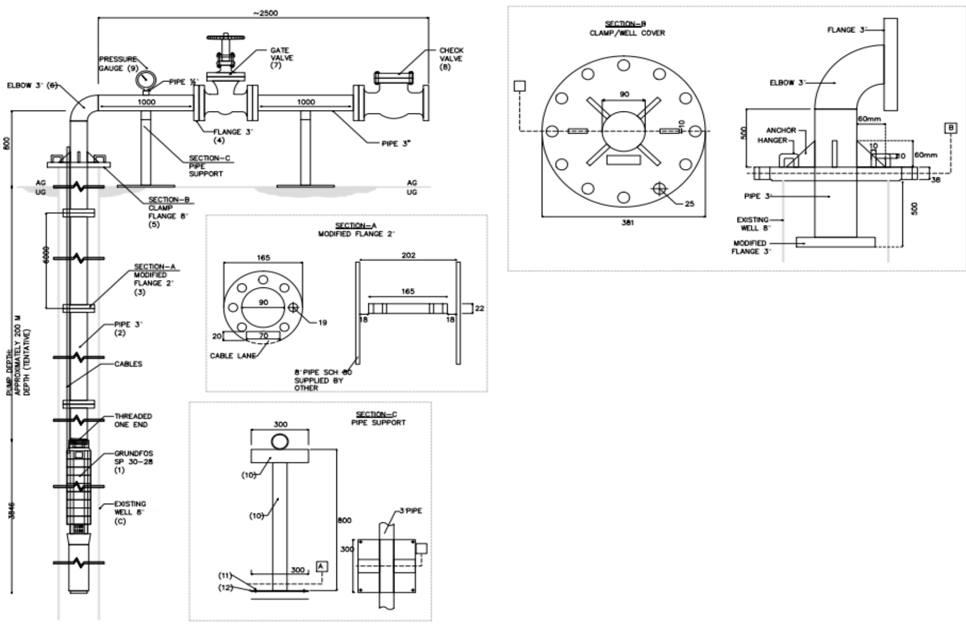

Figure 3. Drawing of Piping Installation for Deep Well Pumps

3.4 Analysis
Based on manual and FEA (solidworks) calculations, it is concluded that the flange can withstand the load of the deep well pump piping systemThe "Results" and "Discussion" sections of a journal article are key parts of the research. Here's what they typically contain:

4. CONCLUSION
Based on explained above, it can be conclude that:

- Based on Calculation, it is found that the thickness of the 3 inch pipe riser is 4,292 mm and the schedule number for the pipe riser is Sch 40.
- Based on Calculation,the minimum size of the welding fillet for the pipe and flange is 5.05 mm to withstand internal forces and normal forces. However, the actual design uses s = 6 mm.
- The ASME B31.8 document will be used as a reference for the selection of materials used for well water service (A53 Gr. B Pipe). However, the actual flange rating selection is based on design calculations.
- There will be some modifications made to the flange, the modification uses a 2 inch flange and there will be a machining process on the inner diameter of the flange to match the inner diameter dimensions of the 3 inch pipe, so detailed information on the modification of the flange can be seen in appendix 1.
- Based on the calculation, the normal force and internal pressure acting on the 2“ and 8” flanges do not exceed the allowable stress of the material. Therefore, this modification can be used for riser pipe installation.
- Based on the calculation of allowable stress for fillet welding, it is able to withstand the normal force and internal pressure acting on the pipe and pipe riser flange.
- The highest average treatment between varieties and spacing on crude protein of corn forage is NK-212 at 9.44% and a spacing of 80 x 20 cm at 9.02%, crude fat of corn forage is Pioneer-36 at 4.56% and a spacing of 60x20 cm at 4.47% and crude fiber of corn forage is NK-212 at 27.40% and with a spacing of 60x20 cm at 26.83%..

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