CHAPTER I

INTRODUCTION

1.1 Background

Oil and natural gas play a key role in supplying Indonesia's energy needs. Although the world is initiating green energy as an effort to reduce excess carbon emissions, oil and gas still play a key role in the energy industry and are still the main energy suppliers in Indonesia [1]. This can be seen in the energy industry's efforts to continue to increase the number of oil wells to increase the amount of oil and gas production produced[2]. Oil and gas that has been sucked from the earth, will be flowed to the oil terminal for the separation process between oil, gas, and impurities. The distribution of petroleum liquids that usually have a fairly hot temperature requires a good piping installation so that the oil and gas that has been mined can be distributed properly.

Pipes that flow hot liquids with a long enough path can fail and break (buckling) due to thermal stress and share stress received by the pipe[3]. Pipe failure can be in the form of bending or what is usually called upheaval buckling, namely pipe failure in the form of bending deformation which is able to occurs both on the pipe walls and throughout the pipe. This deformation failure causes the pipe to bend vertically upwards[4]. To mitigate the thermal displacement which is the cause of the appearance of thermal stress in the pipe, an expansion loop is needed[4]. Expansion loop is a method used to increase flexibility in pipelines[5]. The expansion loop has 3 types, namely U type loop, horseshoe loop and full loop. An optimized expansion loop design will significantly save the amount of material and the number of supports used in the piping system. However, the installation of expansion loops can cause new problems due to changes in the piping pattern that will result in changes in flow[4]. Flow in pipelines is generally focused on the velocity distribution pattern. Fluid phenomena in the pipeline are related to changes in velocity, flow type (laminar, turbulent, or a combination) and changes in the shape of the pipe cross section[6]. These can provide internal loads that are significant enough to affect the stresses that occur in the pipe. If the stress exceeds the allowable stress of the pipe material, it will damage the pipe.

Based on the safety aspect of its operation, the internal load that works must be able to be withstood by a piping system, namely the fluid flowing in it. One of the phenomena that needs to be considered in the design of a pipeline system is the stress arising from the load. The impact of stresses that exceed the limit can be in the form of displacement of the position and geometry of the piping system (loop). In this final project research will further discuss the stress analysis of the expansion loop at national oil and gas company in area BLSE 32 Quintet Wells. The fig.1 was the inspiration of the research, which is the design of the pipeline in BLM Area by Pertamina Hulu Rokan.

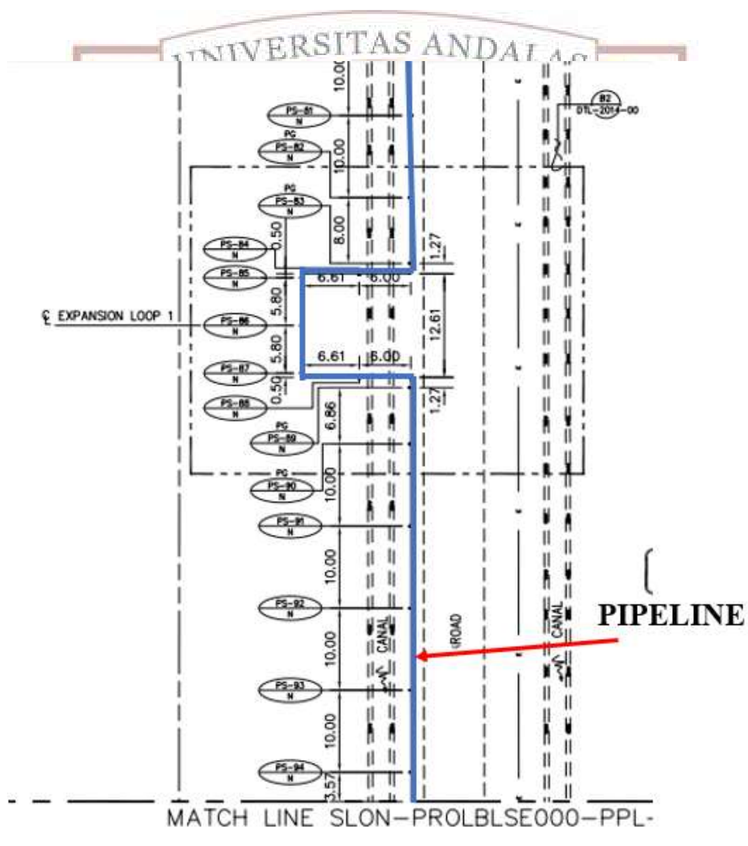

Fig.1 Mechanical drawing pipeline design of BLSE 32 area

Pipeline BLSE 32 Quintet wells will be used as a reference in stress analysis by varying the type and position of the expansion loop. So it is hoped that this final project research can help overcome piping system failures caused by stress due to internal loads and can be used as a consideration in choosing the right type of expansion loop and meeting the safe limit of stress with reference to ASME B31.3.

1.2 Research Questions

Based on the background above, we derived the problem bellow:

1. How does the loop type variation affect the flow pattern in the pipe?
2. How is the stress and deflection of each type of expansion loop in the presence of internal flow?
3. How does the variation of position expansion loop affect the flexibility and stress of the pipe?

1.3 Objectives

The objectives of the research are:

1. To evaluate the effect of loop variation on the flow pattern in the pipes.
2. To evaluate the stress and deflection of each type of expansion loop in the presence of internal flow.
3. To know the effect of the variation of position of expansion loop to flexibility and stress values of the pipe.

1.4 Scopes

The scopes of the research are:

1. The research will be done by simulation
2. The inner pipe wall is considered smooth (smooth wall)
3. The temperature distribution is assumed same and equal in along the pipeline.

CHAPTER II

LITERATURE REVIEW

2.1 Expansion Loop

Pipes that flow hot liquids with a long enough path can fail and break (buckling) due to thermal stress and share stress received by the pipe[3]. Based on Hariono in ‘Ubaid, Pipe failure can be in the form of bending or what is usually called upheaval buckling, namely pipe failure in the form of bending deformation which can occurs both on the pipe walls and throughout the pipe. This deformation failure causes the pipe to bend vertically upwards[4]. To mitigate the thermal displacement which is the cause of the appearance of thermal stress in the pipe, an expansion loop is needed[4]. Expansion loop is a method used to increase flexibility in pipelines[5]. The expansion loop, involving the addition of a loop to the pipe, aims to allow the pipe to undergo expansion without causing stress that could jeopardize the pipe's integrity.

Figure 2. 1 Expansion loop

The pipe system's flexibility is increased by the use of piping expansion loops. Legs perpendicular to the main pipe system are supplied in order to lessen the displacement and produced expansion stress caused by thermal expansion or contraction. The length of the expansion loop is the name given to this perpendicular measurement. The pipe system will benefit more from an expansion loop leg length of this kind. However, the cost, vibration inclination, and support practicality put a limit on this leg length. For this reason, in an expanding loop, the absorbing leg's length is determined only by meeting the stress qualification criteria.[4]

2.2 Allowance for expansion

All pipes will be installed at ambient/surrounding temperature. Pipes carrying high temperature of fluids such as water or oil operate at higher temperatures.
It follows that they expand, especially in length, with an increase from ambient to working temperatures[4]. This will put strain on some parts of the distribution system, such the pipe joints, which might ultimately shatter.. The amount of the expansion is readily calculated using Equation below

$$\Delta L = L\,\Delta T\,\alpha \qquad (2.1)$$

Where:

ΔL =Amount of expansion (m)

L = length of the pipeline (m)

ΔT = temperature difference (°c)

α = thermal conductivity (W/m.K)

2.3 Expansion fittings

One technique for accounting for expansion is the expansion fitting. Other expansion fittings can be made from the pipework itself. This can be a cheaper way to solve the problem, but more space is needed to accommodate the pipe.

2.3.1 Full loop

This is just one full turn of the pipe, and to avoid condensate building up on the upstream side, steam piping should ideally be installed in a horizontal orientation rather than a vertical one. Full loop geometry is shown in figure 2.2

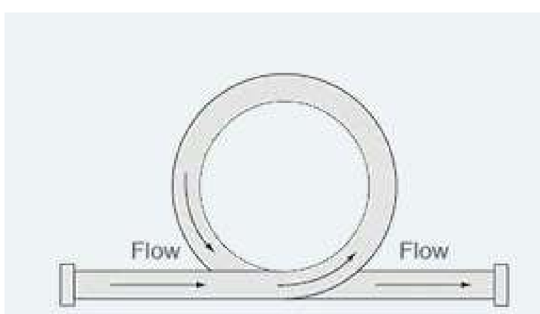

Figure 2. 2 Full loop

Due to the pipework's large footprint and the increased availability of patented expansion bellows, this design is rarely utilized anymore. Nonetheless, because space is typically available and the cost is generally affordable, complete loop type extension devices are still frequently used by big steam users, such as power plants or facilities with extensive outside distribution networks.

2.3.2 Horseshoe or lyre loop

This kind is occasionally utilized when there is room. The loop and the main should be on the same plane when it is fitted horizontally. Although pressure seldom blows the loop's ends apart, it does have a very modest straightening out effect. This is a result of the design, however the flanges are not misaligned as a result.

A drain point has to be installed on the upstream side of the pipe if any of these configurations have the loop installed vertically above the pipe, as shown in Figure 2.3.

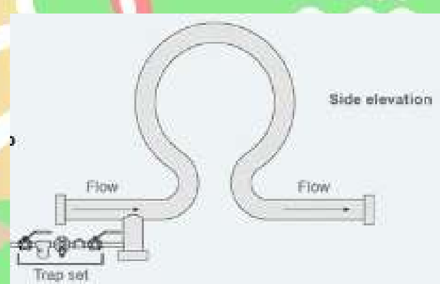

Figure 2. 3 Lyre loop

2.3.3 Expansion Loops Type U

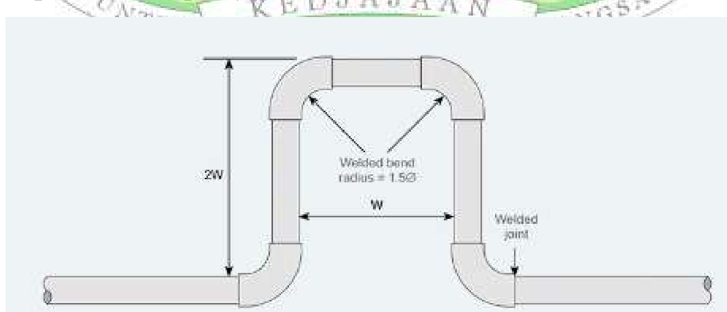

Figure 2. 4 Expansion loop type- U

It can be seen from Figure 2.4 that the depth of the loop should be twice the width, and the width is determined by the diagram and formula below , knowing the total amount of expansion expected from the pipes either side of the loop.

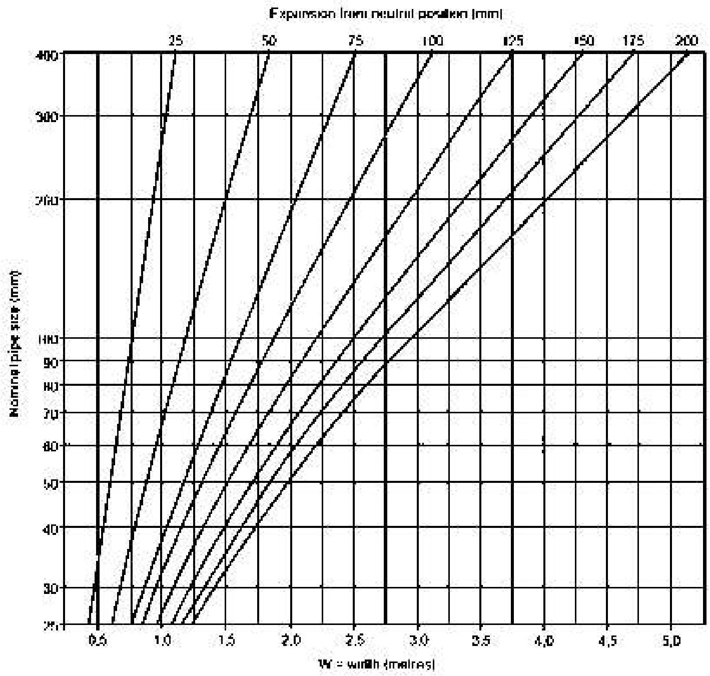

Figure 2. 5 Expansion loop chart

The expansion loop can be fabricated from lengths of straight pipes and elbows welded at the joints. An indication of the expansion of pipe that can be accommodated by these assemblies is shown in Figure 2.5.

2.4 Fluid Flow in Pipes

The condition assumed is that when the pipe is completely filled with the fluid being moved, the main driving force is the pressure gradient along the pipe. This is what causes the fluid in the flow to flow in the pipe, changes in pressure can occur due to changes in height, changes in speed due to changes in cross-sectional area and what happens between the fluid and the pipe wall.

2.4.1 Reynold number

In fluid mechanics, the Reynolds number is the ratio between inertial force and viscous force which quantifies the relationship between these two forces with a certain flow condition or can be written as follows:

$$Re = (\rho \, v \, D)/\mu \tag{2.2}$$

where:

V = velocity of fluid (m/dt)

D = pipe's diameter (m)

ρ = density (kg/m3)

μ = dynamic viscosity (N.s/m3)

The laminar, turbulent, or transitional flow profile may be determined by measuring the Reynolds number that is present in the pipe flow.

2.4.2 Turbulence Kinetic Energy

TKE can be produced by fluid shear, friction or buoyancy, or through external forcing at low-frequency eddy scales (integral scale). Turbulence kinetic energy is then transferred down the turbulence energy cascade, and is dissipated by viscous forces at the Kolmogorov scale.

In oil pipeline systems, **kinetic energy turbulence** can cause several negative effects, including:

- **Pressure loss (head loss)** – Turbulence increases fluid friction with the pipe walls, leading to pressure drops that reduce the efficiency of oil flow.
- **Pipe erosion** – Strong turbulent flow can cause faster wear on the inner surface of the pipes, especially at bends and junctions.
- **Increased energy consumption** – Pumps must work harder to compensate for pressure losses due to turbulence, raising energy costs and operational expenses.
- **Uneven flow distribution** – Turbulence can make oil flow unstable, disrupting the separation and processing stages.

  To mitigate these effects, solutions such as more aerodynamic pipeline designs, erosion-resistant materials, or more accurate turbulence models in fluid flow simulations can be applied.

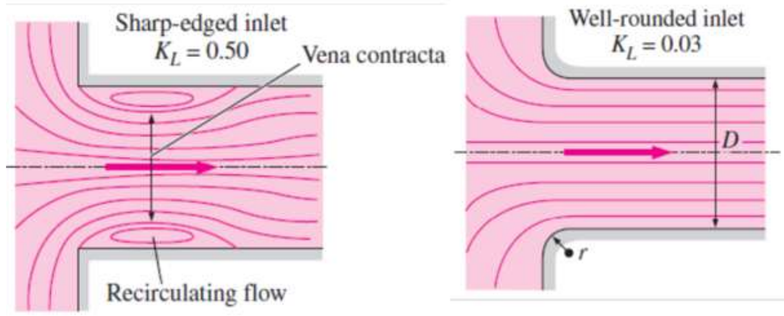

Figure 2. 6 Sharp and circular arcs flow pattern

The losses during changes of direction can be minimized by making the turn "easy" on the fluid by using circular arcs instead of sharp turns. All the kinetic energy of the flow is "lost" (turned into thermal energy) through friction as the jet decelerates and mixes with ambient fluid downstream of a submerged outlet.[7]