Structural analysis of non-linear pipe bends

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ABSTRACT

Pipe bends are most important necessary for all kind of industries in terms of pipelining materials. Pipe bend is very difficult to avoid thickening on the inner side of the pipe bend and thinning of the outer side of the pipe bend. The cross-section also becomes non-circular due to bending process; this tends to cause ovality and thinning in pipe bends. ovality is the main cause to fail the pipe. This study is an attempt to analyze the stainless steel tube. We are going to apply both internal load an external load on the pipe. The internal load we are applying as pressure and external load we are going to applying by using spring balance the stainless steel tube with Diameter 42.2mm and thickness 3mm and bend radius of 250 mm for the percentage of ovality varied from 0 to 20 is considered for doing the analysis. The pipe bend geometry is imported into ANSYS as IGES file and the convergence study was performed. Workbench option is invoked in the analysis for better results. The results of the analysis presented in the form of total deflection and stresses for incremented internal pressure was computed for the various percentage of ovality. During this process, the bend undergoes plastic instability due to pressure and bending. Pipe bends improve the pipe quality and trustworthiness in terms of pipe bend analysis. Finally, the induced stress intensity and deformation of the pipe due to internal pressure and bending were noted.

Keywords: Pipe bends, Ovality, Non-linear pipe bends.

1. INTRODUCTION

Generally, for elbows, there is high conservatism in the sense that the experimental loads are greater than those predicted. Pipe bend is very difficult to avoid the thinning on the inner side of the bend and thinking of the outer side of the bend. Therefore, with an increase in temperature, the pipe is stretched by the expanding liquid and the liquid is compressed by the confinement of the pipe. The pipelines used to transport heated fluids experience changes in their free length with a change in temperature of the fluids. Pipe bends are used extensively in power plants to convey fluids and to change the direction of the fluids flowing inside the pipes. During operation, pipe bends with thinning are subjected to higher stresses than pipe bends with perfectly circular cross-sections. The structural integrity and cost of pipelines are of major concern in oil, chemical, and other industries. Pipelines can be subjected to severe thermal, pressure, and other mechanical loads. The pipelines used to transport heated fluids experience changes in their free length with a change in temperature of the fluids. In the general case, most liquids expand thermally more per unit volume than does the pipe volume. Therefore, with an increase in temperature, the pipe is stretched by the expanding liquid and the liquid is compressed by the confinement of the pipe. The bend section is the weaker part in high-pressure application because the pipe bend will be made with the ovality. In this project, we are going to apply both external and internal load on pipes. We are going to apply internal load as the pressure which will control by a pressure regulator and external load as weights by using the weighing machine.

1.1 Purpose of the pipe bend

A smooth pipe bends are an important component in a piping work system. Normally, pipe systems are designed with sufficient directional changes to suit the available working space and also to provide inherent flexibility to compensate for expansion and contraction. The pipe bends and the U-shape pipeline system (which is fabricated with 90-degree elbows and straight pipe) may be used in any piping system. It is very difficult to avoid...
1.2 DEFINITION

Ovality or Noncircularity
It is the ratio of the difference between the major diameter and minimum diameter by the nominal diameter of the pipe

\[
 Ovality of pipe \quad c_o = \frac{D_{MAX} - D_{MIN}}{D_O} \tag{1}
\]

Ovality in percentage

\[
 Ovality in percentage \quad c_o = \frac{D_{MAX} - D_{MIN}}{D_O} \times 100 \tag{2}
\]

WHERE:

\[
 D_o = \frac{D_{MAX} + D_{MIN}}{2} \tag{3}
\]

Thinning
It is the ratio of the difference between the nominal thickness and minimum thickness by the nominal thickness of the pipe. When expressed in the percentage

\[
 c_t = \frac{t - t_{MIN}}{t} \times 100 \tag{4}
\]

Thickening
It is the ratio of the difference between the maximum thickness and nominal thickness to the nominal thickness of the pipe bend. When expressed in percentage

\[
 c_{th} = \frac{t_{MAX} - t}{t} \times 100 \tag{5}
\]

Maximum outer diameter
It is the maximum diameter of the pipe where the bending occurs

\[
 D_{MAX} = D_o + 2X \tag{6}
\]

Minimum outer diameter
It is the minimum diameter of the pipe where the bending occurs

\[
 D_{MIN} = D_o - 2X \tag{7}
\]

2. ANALYSIS

METHODOLOGY
First, we are going to find the problem faced in the pipes then by using experimental setup and ANSYS software we are going to evaluate the results and then we will compare the values and obtain the results

FINITE ELEMENT ANALYSIS

The finite element model and analysis are carried out by using the software ANSYS or ABAQUS. Then we are going to import from initial graphics exchange specification (IGES) to analysis package. We are going to use mesh element size as 3mm.
are going to apply boundary condition. We are going to find with support on bend section, with support on-axis line and without support on pipe bends.

**MESHING**

Meshing is the most important feature in analysis software. Meshing is an integral part of the computer-aided simulation software. When the load is applied to the structure or body the load is distributed uniformly on the structure. We have given the mesh as 3mm.

**Experimental and FEA Analysis Values**

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The graph plotted for pressure and deformation

**Experimental Setup:**
3. RESULTS AND DISCUSSIONS

The application of internal pressure changes the way of pipe bend behaves under internal pressure loading, not only in terms of its load-deflection behavior but also in terms of distribution of stresses and strains. In this study, Stress analysis of stainless steel pipe without attached pipe was developed and plotted to the various ovality in pipe bend. The results indicate that the pipe that meets the specified minimum stress is not appreciably failure up to the 20% ovality.

**Ovality 20%, pressure 26 bar**

Without support: MTD=2.9631
With support on bend section: MTD=0.71461
With support on axis line: MTD=1.6429

**Ovality 20%, pressure 22 bar**

Without support: MTD=2.9522
With support on bend section: MTD=0.71197
With support on axis line: MTD=1.637

**Ovality 20%, pressure 18 bar**

Without support: MTD=2.9424
With support on bend section: MTD=0.70962
With support on axis line: MTD=1.6318

**Ovality 20%, pressure 14 bar**

Without support: MTD=2.9327
With support on bend section: MTD=0.70727
With support on axis line: MTD=1.6266
Ovality 20%, pressure 10 bar

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<th>Equivalent (von-Mises) stress Without support</th>
<th>Equivalent elastic strain Without support</th>
<th>Total deformation with support on bend section</th>
<th>Equivalent (von-Mises) stress with support on bend section</th>
<th>Equivalent elastic strain with support on bend section</th>
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<th>Equivalent (von-Mises) stress with support on axis line</th>
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Compare to three of them with support on bend section can withstand more pressure.
4. CONCLUSION

In this study, Stress analysis STAINLESS STEEL pipe was developed and plotted to the various ovality in pipe bend by using support and without support. The influence of ovality on the variation of von mises stress, total deformation and stress intensity of pipes are calculated by ansys software and for experimental we are using as pressure and we calculate the ovality of the pipe. It is subjected to many different kinds of loading but for purpose three categories of codes of loads sustained load, occasional load, and expansion load. Compare to three of them with support on bend section can withstand more pressure load.

5. REFERENCES

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NOMENCLATURE

C_o - Percentage of ovality,
C_t - Thinning
C_th - Thickenning
P - Internal design pressure
D - Diameter of pipe mean pipe radius (mm)
P - Internal pressure

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