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# 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.*

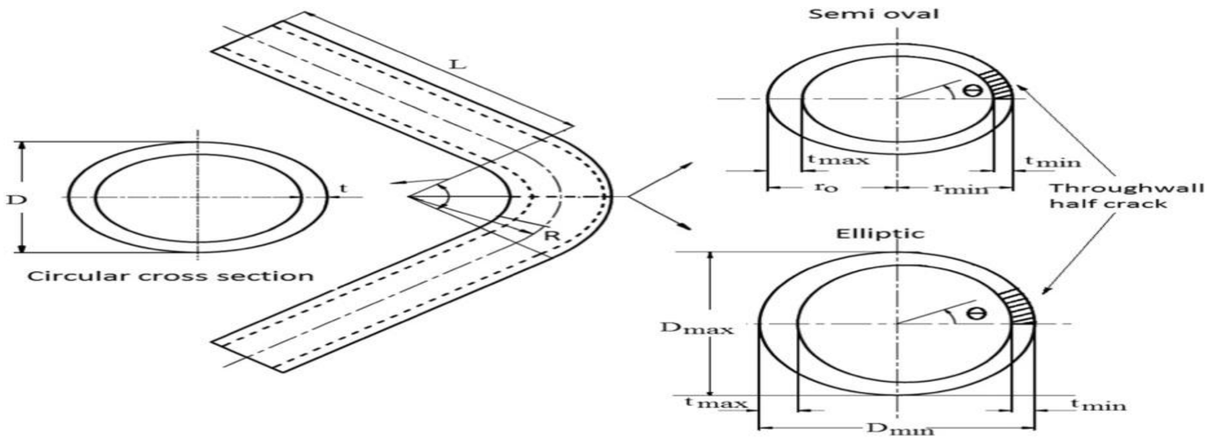
## 1. INTRODUCTION

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 $c_{o}=\frac{D_{MAX}-D_{MIN}}{D_O}$------------------------------------------------(1)

Ovality in percentage

$c_{o}=\frac{D_{MAX}-D_{MIN}}{D_O}*100$----------------------------------------------------(2)

WHERE;

$D_{o}=\frac{D_{MAX}+D_{MIN}}{2}$-------------------------------------------(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

$c_t = \frac{t-t_{min}}{t} * 100$------------------------------------------------------------------------------- (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

$c_{th} = \frac{t_{max}-t}{t} * 100$---------------------------------------------------------------------------- (5)

Maximum outer diameter

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

$D_{max} = D_o + 2X$------------------------------------------------------------------------(6)

Minimum outer diameter

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

$D_{min} = D_o - 2X$-------------------------------------------------------------------------- (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

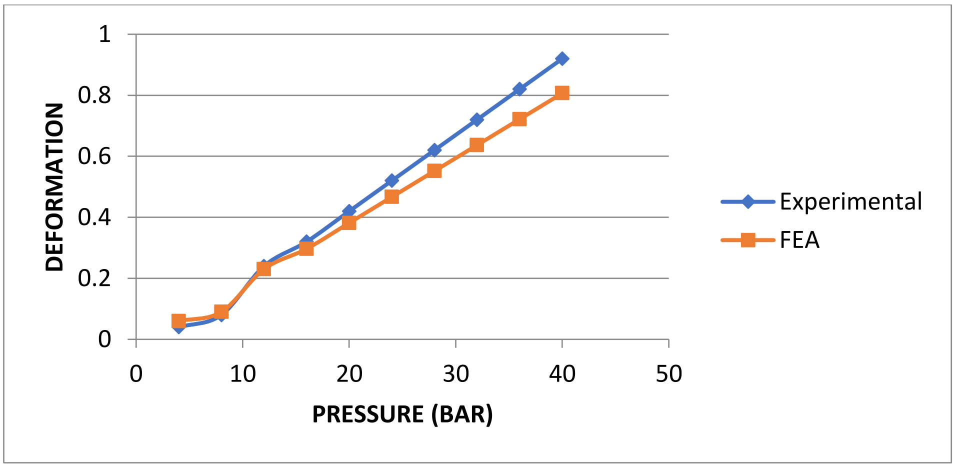
The finite element model and analysis are carried out by using the software ANSYS or ABAQUS .Then we are going to import from initial graphics exchange specification (IGES) to analysis package. We are going to use mesh element size as 3mm .then we are going to apply boundary condition.We are going to 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**

| Pressure | Deformation | |
|---|---|---|
| | Experimental | FEA |
| 4 | 0.04 | 0.06 |
| 8 | 0.08 | 0.09 |
| 12 | 0.24 | 0.23 |
| 16 | 0.32 | 0.29 |
| 20 | 0.42 | 0.38 |
| 24 | 0.52 | 0.46 |
| 28 | 0.62 | 0.55 |
| 32 | 0.72 | 0.63 |
| 36 | 0.82 | 0.72 |
| 40 | 0.92 | 0.8066667 |



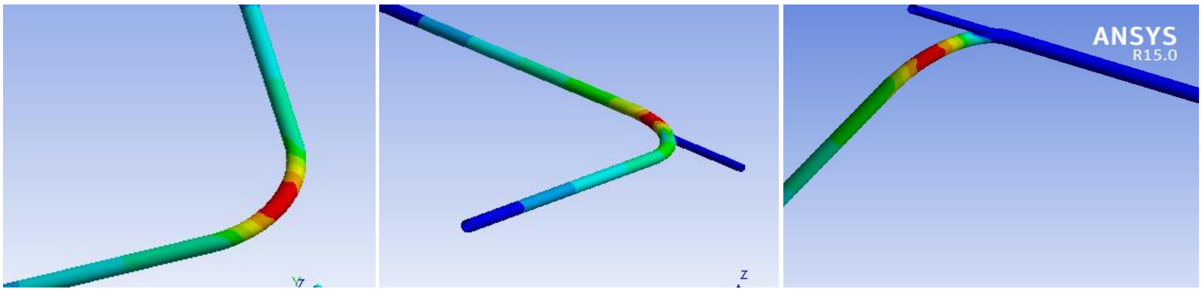

The graph plotted for pressure and deformation

**Experimental Setup:**

## 3. RESULTS AND DISCUSSIONS

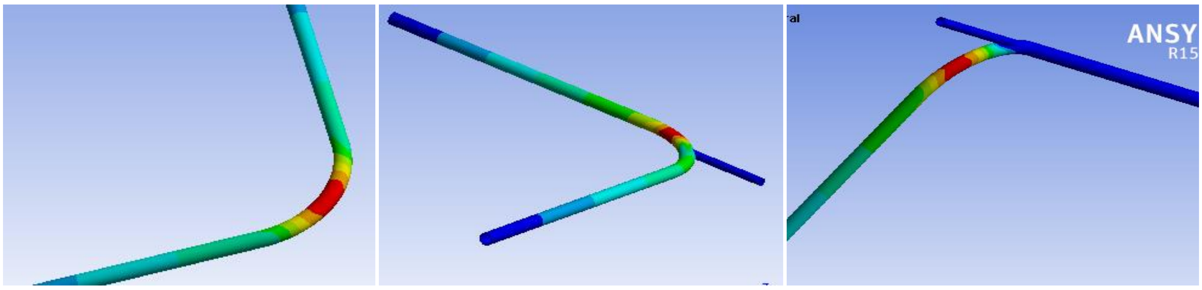
The application of internal pressure changes the way of pipe bend behaves under internal pressure loading, not only in terms of its load-deflection behavior but also in terms of distribution of stresses and strains. In this study, Stress analysis of stainless steel pipe without attached pipe was developed 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**



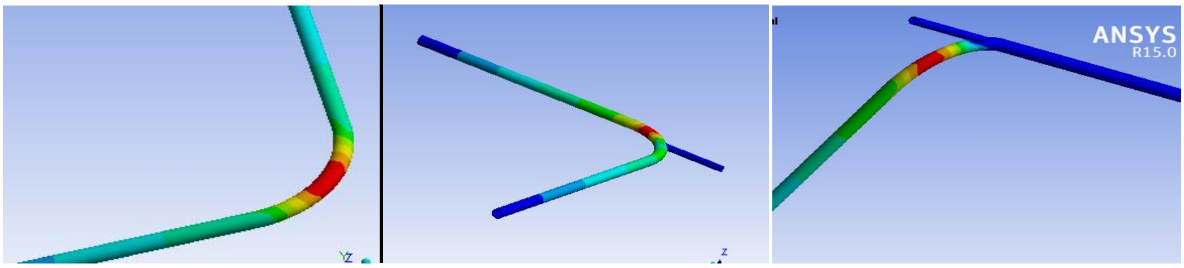
Without support MTD=2.9631 | with support on bend section MTD=0.71461 | with support on axis line MTD=1.6429

**Ovality 20%, pressure 22 bar**



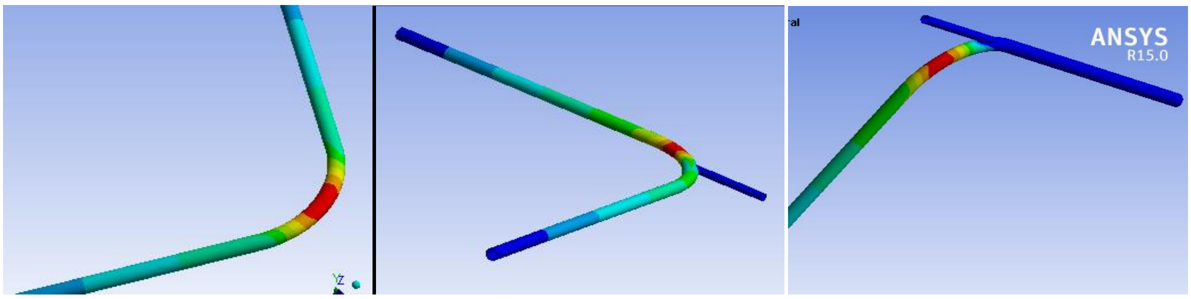
Without support MTD=2.9522 | with support on bend section MTD=0.71197 | with support on axis line MTD=1.637

**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

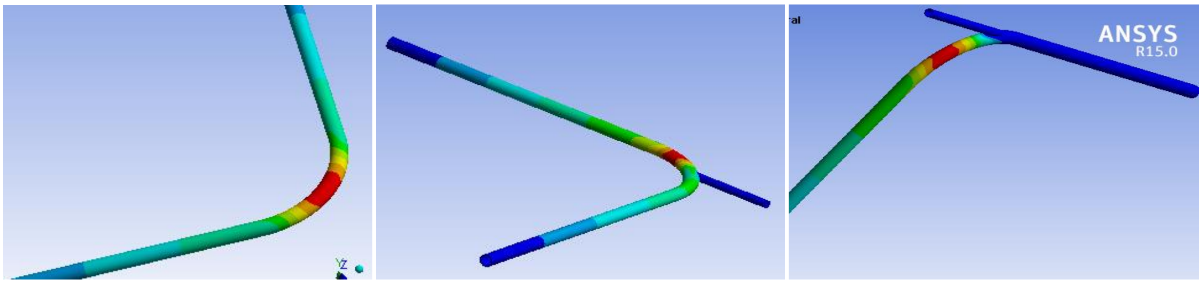
**Ovality 20%, pressure 14 bar**



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**




Without support | with support on bend section | with support on axis line

MTD=2.923 | MTD=0.70493 | MTD=1.6214

Compare to three of them with support on bend section can withstand more pressure

**Maximum Stress Value for Pipe Bend**

| Ovality | pressure | Total deformation Without support | Equivalent(von -mises) stress Without support | Equivalent elastic strain Without support | Total deformation with support on bend section | Equivalent(von -mises) stress with support on bend section | Equivalent elastic strain with support on bend section | Total deformation with support on axis line | Equivalent(von -mises) stress with support on axis line | Equivalent elastic strain with support on axis line |
|---|---|---|---|---|---|---|---|---|---|---|
| 0% | 10 | 2.8315 | 1696.8 | 0.0087918 | 0.64169 | 1874.9 | 0.01048 | 1.3253 | 1966.9 | 0.010191 |
| | 14 | 2.8384 | 1700.5 | 0.0088108 | 0.64336 | 1878.9 | 0.010502 | 1.3284 | 1971.5 | 0.010215 |
| | 18 | 2.8453 | 1704.1 | 0.0088298 | 0.64503 | 1882.9 | 0.010524 | 1.3316 | 1976.1 | 0.010239 |
| | 22 | 2.8522 | 1707.8 | 0.0088487 | 0.6467 | 1886.9 | 0.010547 | 1.3347 | 1980.7 | 0.010263 |
| | 26 | 2.86 | 1711.9 | 0.00887 | 0.64858 | 1891.5 | 0.010571 | 1.3382 | 1985.9 | 0.01029 |
| 4% | 10 | 2.8492 | 1962.1 | 0.010166 | 0.64841 | 1879.7 | 0.010397 | 1.3407 | 2052.2 | 0.010633 |
| | 14 | 2.8566 | 1966.4 | 0.010189 | 0.6502 | 1883.4 | 0.010417 | 1.3442 | 2056.4 | 0.010655 |
| | 18 | 2.8641 | 1970.8 | 0.010211 | 0.65199 | 1887 | 0.010437 | 1.3478 | 2060.6 | 0.010677 |
| | 22 | 2.8715 | 1975.2 | 0.010234 | 0.65378 | 1890.7 | 0.010457 | 1.3513 | 2064.7 | 0.010698 |
| | 26 | 2.8799 | 1980.1 | 0.01026 | 0.65579 | 1894.8 | 0.01048 | 1.3552 | 2069.4 | 0.010723 |
| 8% | 10 | 2.8614 | 1988.2 | 0.010309 | 0.64559 | 2044.9 | 0.011051 | 1.3504 | 2169.6 | 0.011241 |
| | 14 | 2.8694 | 1992.5 | 0.010331 | 0.64751 | 2048.3 | 0.01107 | 1.3543 | 2173.7 | 0.011263 |
| | 18 | 2.8774 | 1996.8 | 0.010354 | 0.64943 | 2051.7 | 0.011089 | 1.3582 | 2177.9 | 0.011284 |
| | 22 | 2.8855 | 1756.6 | 0.0091016 | 0.65135 | 2055.1 | 0.011108 | 1.3621 | 2182.1 | 0.011306 |
| | 26 | 2.8935 | 1760.2 | 0.0091204 | 0.65351 | 2058.9 | 0.01113 | 1.3665 | 2186.7 | 0.01133 |
| 12% | 10 | 2.8838 | 2012.6 | 0.010435 | 0.6503 | 1772.3 | 0.0091831 | 1.4503 | 2448 | 0.012711 |
| | 14 | 2.8924 | 2016.9 | 0.010458 | 0.65234 | 1777.4 | 0.0092096 | 1.4546 | 2452.1 | 0.012732 |
| | 18 | 2.9009 | 2021.2 | 0.01048 | 0.65438 | 1782.5 | 0.009236 | 1.459 | 2456.2 | 0.012754 |
| | 22 | 2.9095 | 2025.5 | 0.010502 | 0.65641 | 1787.6 | 0.0092624 | 1.4633 | 2460.3 | 0.012775 |
| | 26 | 2.9191 | 2030.4 | 0.010528 | 0.65871 | 1793.4 | 0.0092922 | 1.4682 | 2464.9 | 0.012799 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 16% | 10 | 2.9052 | 2036 | 0.010549 | 0.65624 | 1952.2 | 0.010864 | 1.4587 | 2494.9 | 0.012973 |
| | 14 | 2.9145 | 2040.3 | 0.010571 | 0.65844 | 1959.3 | 0.010908 | 1.4636 | 2498.6 | 0.012992 |
| | 18 | 2.9237 | 2044.6 | 0.010594 | 0.66065 | 1966.5 | 0.010953 | 1.4684 | 2502.4 | 0.013011 |
| | 22 | 2.9329 | 2048.8 | 0.010616 | 0.66286 | 1973.6 | 0.010998 | 1.4732 | 2506.1 | 0.01303 |
| | 26 | 2.9433 | 2053.6 | 0.010641 | 0.66535 | 1981.7 | 0.011048 | 1.4786 | 2510.3 | 0.013052 |
| 20% | 10 | 2.923 | 2061 | 0.010679 | 0.70493 | 2033.3 | 0.011321 | 1.6214 | 3023.8 | 0.01586 |
| | 14 | 2.9327 | 2065.2 | 0.010701 | 0.70727 | 2042.8 | 0.01138 | 1.6266 | 3027.2 | 0.015877 |
| | 18 | 2.9424 | 2069.5 | 0.010723 | 0.70962 | 2052.4 | 0.011439 | 1.6318 | 3030.6 | 0.015894 |
| | 22 | 2.9522 | 2073.7 | 0.010745 | 0.71197 | 2062 | 0.011499 | 1.637 | 3034 | 0.015911 |
| | 26 | 2.9631 | 2078.5 | 0.010769 | 0.71461 | 2072.8 | 0.011565 | 1.6429 | 3037.8 | 0.015931 |

## 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


[1] S.Sellakumar and R.Venkatasamy(2015). Review of structural assessment of pipe bends. International review of MechanicalEngineering2013.vl7.n.6.pp.1180-88

[2] T. Christo Michael*, A.R. Veerappan, S. Shanmugam. Comparison of plastic limit and collapse loads in pipe bends with shape imperfections under in-plane bending and an internal pressure. International Journal of Pressure Vessels and Piping.2012. vl.99.pp.23-33.

[3] A. R.Veerappan and S. Shanmugam. Analysis For Flexibility In The Ovality And Thinning Limits Of Pipe Bends. ARPN Journal of Engineering and Applied Sciences.2008.vl.3.pp.31-41.

[4] B. G. Teng, Hu and S. J. Yuan .Deformation behavior of thin-walled tube bending with internal pressure October 17, 2013.Vl.134.pp.1-7.

[5] Andrea Catinaccio. Pipes under internal pressure and bending.Journal of Pressure Vessel Technology. February 4, 2010. vl.134.pp.345-353.

[6] T. Christo Michael*, A.R. Veerappan, S. Shanmugam(2011). Comparison of plastic limit and collapse loads in pipe bends with shape imperfections under in-plane bending and an internal pressure. International Journal of Pressure Vessels and Piping.2012. vl.99.pp.23-33.

[7] Christo Michael T, SushrutBugde, Srikanth K January 2017. Determination of safe stress limit of high-pressure pipe bends used in chemical industries .vl.30.pp.504-510.

[8] J.m.pardala, .c.desouza,e.c.leaob, m.r.dasilvac, s.s.m.tavaresaoctober 17, 2013. Fatigue cracking of high-pressure .international journal of pressure vessels

[9] V. Polenta, S. D. Garvey, D. Chronopoulos, A. C. Long, H. P. Morvan2015. Effects of pipe curvature and internal pressure on stiffness and buckling phenomenon of circular thin-walled pipes. Journal of Mechanical Science and Technology. Vl.22.pp.647-652.

[10] Mu Seong Chang, Young Il Kwon and Bo SikKang(2009). Design of reliability qualification test for pneumatic cylinders based on performance degradation data. Journal of Mechanical Science and Technology.2014. Vl.28.n.12.pp.4939-45.


## NOMENCLATURE

$C_o$ - Percentage of ovality,

$C_t$ - Thinning

$C_{th}$ - Thickening

P - Internal design pressure

D - Diameter of pipe mean pipe radius (mm)

P - Internal pressure

| | | |
|---|---|---|
| $D_{max}$ | - | Maximum outside pipe diameter (mm) |
| $D_{min}$ | - | Minimum outside pipe diameter (mm) |
| tmin | - | Mininum thickness |
| tmax | - | Maximum thickness |
| t | - | Normal wall thickness |
| Do | - | Nominal diameter of pipe (mm) |