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 tend 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 and external load on the pipe. 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 percentage of ovality varied from 0 to 20 is considered for doing analysis. The pipe bend geometry is imported in to ANSYS as IGES file and the convergence study was performed. Work bench option is invoked in the analysis for better results. .

The results of analysis presented in the form of total deflection and stresses for incremented internal pressure was computed for 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 pipe due to internal pressure and bending were noted.

Nomenclature:

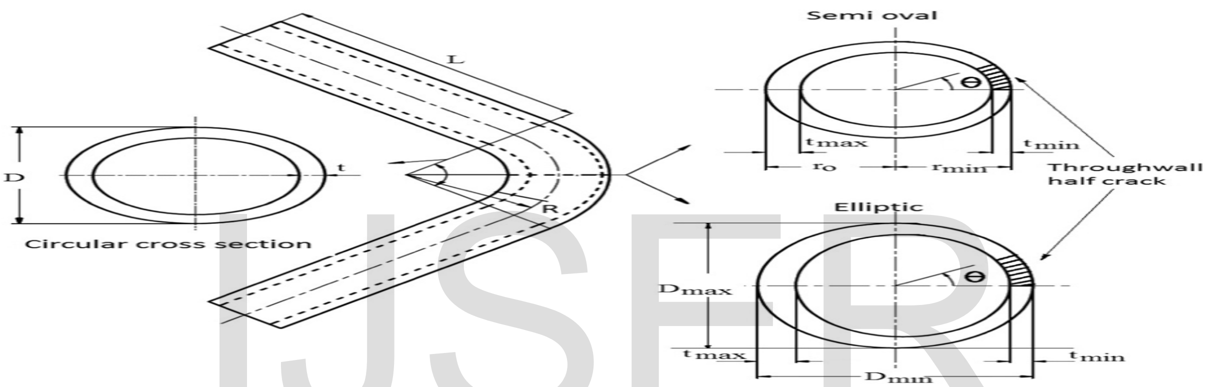
C_o	-	Percentage of ovality,
C_t	-	Thinning
C_{th}	-	Thickening
P	-	Internal design pressure
D	-	Diameter of pipe mean pipe radius (mm)
P	-	Internal pressure
D_{max}	-	Maximum outside pipe diameter (mm)
D_{min}	-	Minimum outside pipe diameter (mm)
tmin	-	Mininum thickness
tmax	-	Maximum thickness
t	-	Normal wall thickness
Do	-	Nominal diameter of pipe(mm)

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 pressure which will controlled by pressure regulator and external load as weights by using weighing machine

1.1 Purpose of pipe bend

A smooth pipe bends are 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 Non circularity

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

$$c_o = \frac{D_{MAX}-D_{MIN}}{D_O} * 100 \quad \text{------------------(2)}$$

WHERE;

$$D_o = \frac{D_{MAX}+D_{MIN}}{2} \quad \text{------------------(3)}$$

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

$$c_t = \frac{t-t_{min}}{t} * 100 \quad \text{------------------(4)}$$

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

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

Maximum outer diameter

It is the maximum diameter of pipe where the bending occurs

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

Minimum outer diameter

It is the minimum diameter of pipe where the bending occurs

$$D_{min} = D_o - 2X \text{---(7)}$$

2.ANALYSIS

METHODOLY

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 resuls and then we will compare the values and obtain the results

FINITE ELEMENT ANALYSIS

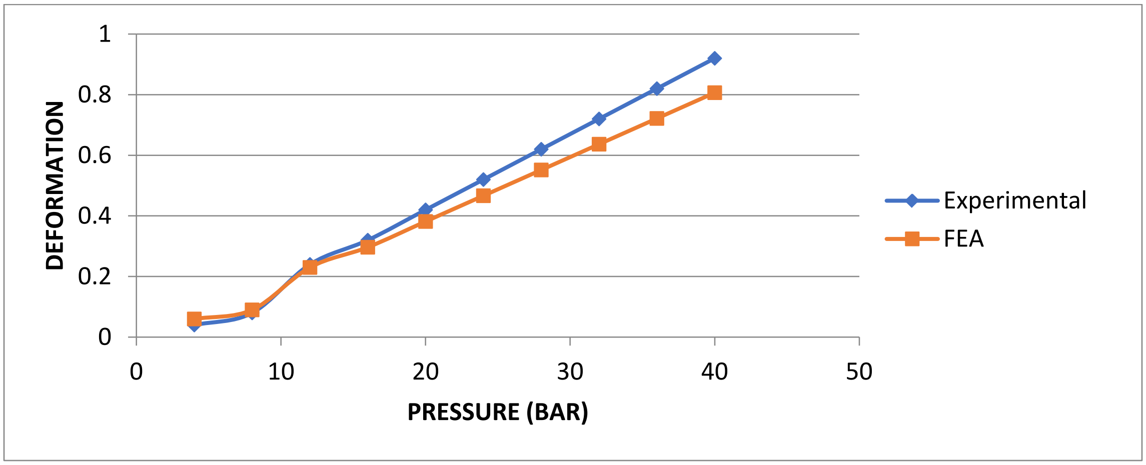
The finite element model and analysis are carried out by using the software ANSYS or ABAQUS .Then we are going to import from initial graphics exchange specification (IGES) to analysis package. We are going to use mesh element size as 3mm .then we are going to apply boundary condition.We are going to 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 softwares. Meshing is an integral part of the computer aided simulation software. when load is applied on 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



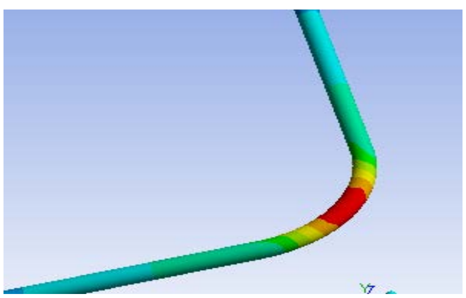
Graph plotted for pressure and deformation

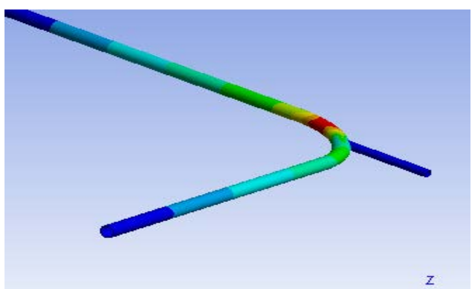
Experimental Setup:

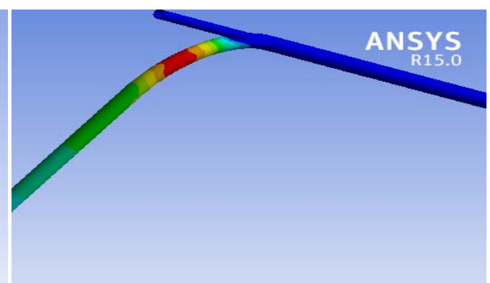
RESULTS AND DISCUSSIONS

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





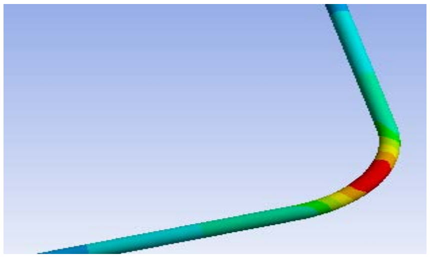
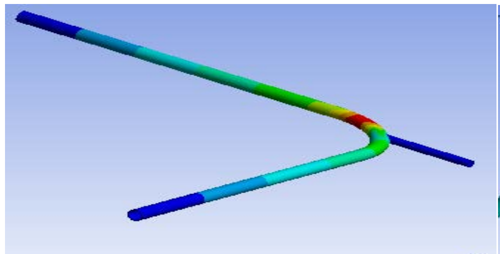
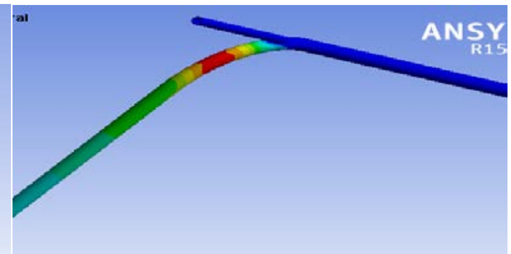


Without support — with support on bend section — with support on axis line

MTD=2.9631 — MTD=0.71461 — MTD=1.6429

ISSN 2229-5518

Ovality 20% , pressure 22 bar

Without support

MTD=2.9522

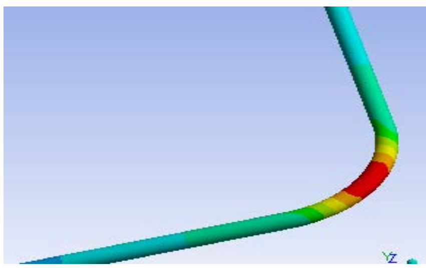
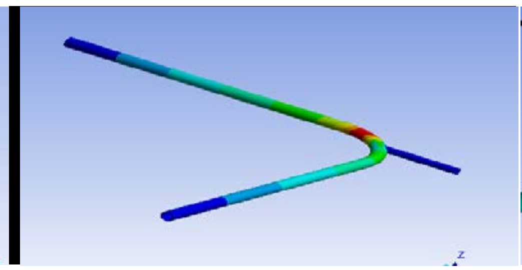
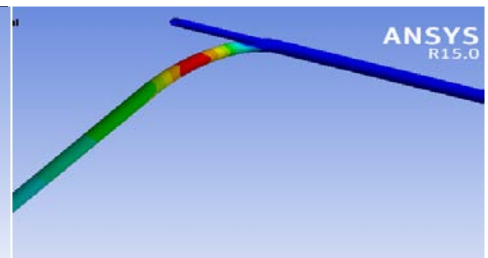
with support on bend section

MTD=0.71197

with support on axis line

MTD=1.637

Ovality 20% , pressure 18 bar

Without support

MTD=2.9424

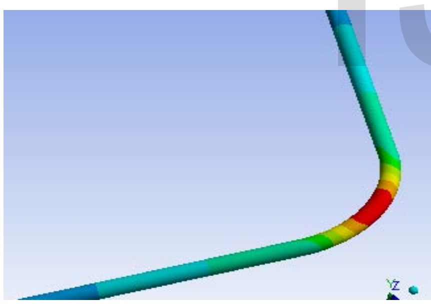
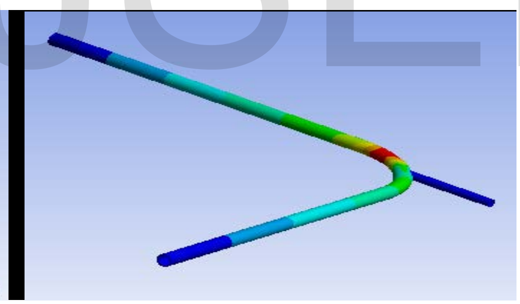
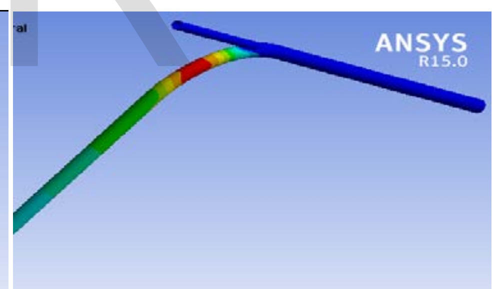
with support on bend section

MTD=0.70962

with support on axis line

MTD=1.6318

Ovality 20% , pressure 14 bar

Without support

MTD=2.9327

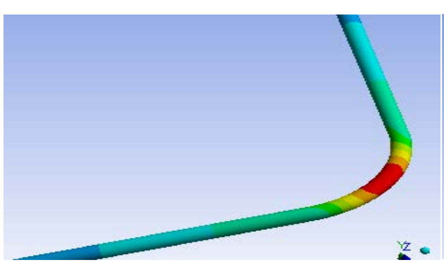
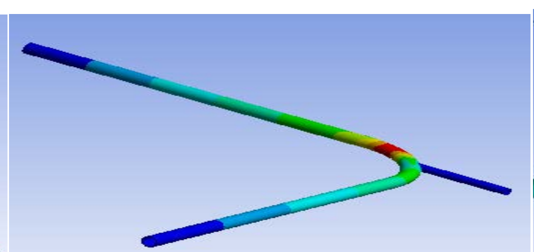
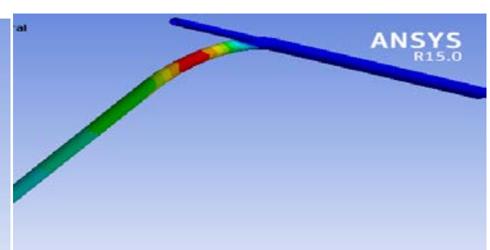
with support on bend section

MTD=0.70727

with support on axis line

MTD=1.6266

Ovality 20% , pressure 10 bar

Without support

MTD=2.923

with support on bend section

MTD=0.70493

with support on axis line

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

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 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 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

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