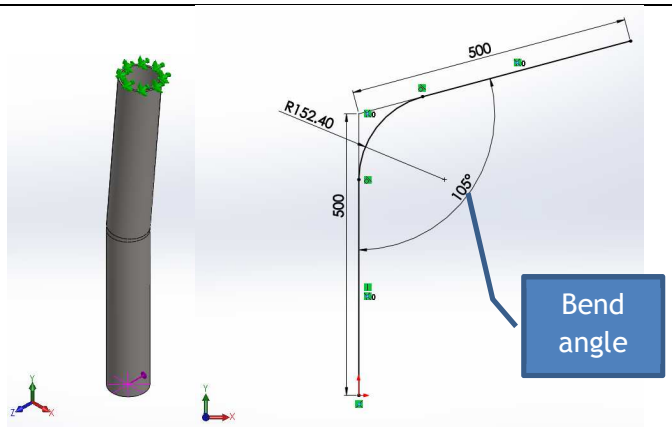
STRESSMAN ENGINEERING



Simulation of Bends

Date: 16. May 2012
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Study name: Design study
Analysis type: Design Study, static

Table of Contents

Description

This report studies the correlation between stresses, SIFs and bend angles of pipe bends due to inplane bending moment. The reason for the initialization of the report was discussion thread in the LinkedIN community and my own curiosity. I hope this report might shed some light on the discussion.

General Input data: (See sketch above)
OD = 114.3 (4ND), WT = 5mm, Bend radius = 152.4mm
Length from bend center to end =500mm.
Bend angle = From 5 degrees to 90 degrees

DISCLAIMER: The analysis, results and conclusion found in this report are based on a quick and shallow FEA and are ONLY for guidance and a SUPPLEMENT to the LinkedIN discussion.

NOTE: The standard SolidWorks Simulation standard report was chosen to ease the reporting time. Please note that this is not common practice at Stressman Engineering. For paid projects we are using more professional and in depth reports.

Assumptions

OD = 114.3 (4ND), WT = 5mm, Bend radius = 152.4mm
Length from bend center to end =500mm.
One end is fixed the other has an in plane bending moment of 1000Nm.
The bending moment will generate a bending stress of 22.4MPa in a straight pipe.

Abbreviations

Deg = Degrees, FEA = Finite Element Analysis, LC = Load case, ND = Nominal diameter, OD = Outer diameter, SIF = Strength intensification Factor, WT = Wall thickness.

Study Properties

Study name	Design Study 1
Analysis type	Design Study
Design Study Quality	High quality (slower)

Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/mm^2 (MPa)

Calculation of SIF

The ASME codes use girth welds as “base lines” /1/. This means that a SIF of 2.0 is already incorporated into the code and its safety factors. Therefore should the peak stress found in an FEA be divided by 2 times the nominal stress in a straight pipe.

$$\boldsymbol{SIF} = \frac{\text{Peak stress}}{2\ Nominal\ stress\ in\ pipe}$$

Design Study Setup

Design Variables

Name	Type	Values	Units
Bend angle	Range with Step	Min:5° Max:90° Step:5°	deg

Constraints

Sensor name	Condition	Bounds	Units	Study name
Stress1 (Von-Mises)	Monitor Only	-	-	Study 1

Study Results

19 of 19 LCs ran successfully.

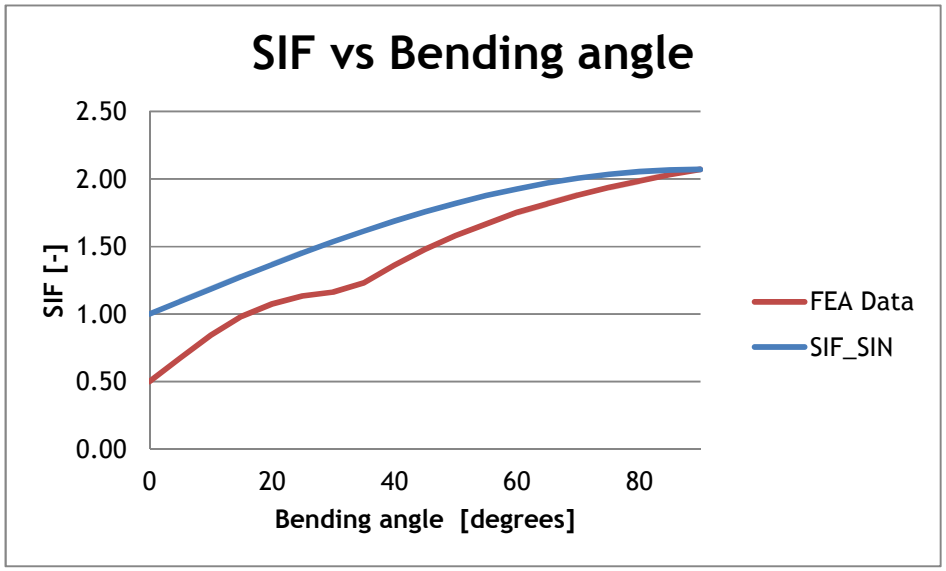
Component	Units	Current	Initial	Optimal	LC1	LC2
Bend angle	Deg	90°	90°	-	90°	85°
Von-Mises	MPa	92.725	92.725	-	92.725	90.968
SIF	-	2.07	2.07		2.07	2.03
Component	**Units**	**LC3**	**LC4**	**LC5**	**LC6**	**LC7**
Bend angle	Deg	80°	75°	70°	65°	60°
Von-Mises	MPa	88.975	86.799	84.225	81.406	78.466
SIF	-	1.99	1.94	1.88	1.82	1.75
Component	**Units**	**LC8**	**LC9**	**LC10**	**LC11**	**LC12**
Bend angle	Deg	55°	50°	45°	40°	35°
Von-Mises	MPa	74.706	70.73	66.176	60.907	55.147
SIF	-	1.67	1.58	1.48	1.36	1.23
Component	**Units**	**LC13**	**LC14**	**LC15**	**LC16**	**LC17**
Bend angle	deg	30°	25°	20°	15°	10°
Von-Mises	MPa	52.123	50.861	48.141	44.036	37.834
SIF	-	1.16	1.14	1.07	0.98	0.84

Component name	Units	LC18
Bend angle	deg	5°
Stress1	MPa	30.163
SIF	-	0.67

Based on the results above a formula has been derived:

$$SIF_{SIN}(\alpha) = (SIN(\alpha) * (SIN(90) - 1)) + 1$$

The SIF_SIN formula and the data found in the FE analyses are plotted together.



ASME B31.3 SIF
The in plane SIF calculated with ASME B31.3 Appendix D is 2.24.

Error sources

This analysis was ONLY performed to get a rough estimate. Potential error sources are mesh and meshing settings, load settings, the 3D model, etc.

Discussion/Conclusion

The ASME B31.3 SIF and the FEA SIF are quite close in values. The ASME B31.3 SIF is slightly more conservative than the results from the FEA.

The SIF_SIN function found corresponds well with the FEA data retrieved from the analysis.

The main conclusion is that an in plane bending SIF for a bend will never be higher than the SIF for 90 degree bend; hence the SIF for a 90 degree bend may be used for all bends with a smaller bend angle.

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Referances

/1/ Paulin Reseach Group - http://www.paulin.com/WEB_Markl_SIFs_ASME_VIII_2.aspx