

# Pipe Stress Analysis Using Caesar II Software

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**Abstract-** Designing of piping system is done keeping in mind international standard codes and company standards. Pipe and piping system are the main part of plant is used for transporting fluid, vapour's and slurries etc. under different condition as per the need of the plant. Piping system made of different components which are valves, tee, bend, elbow and different fittings components. Our main aim is to describe basic concept of Stress Intensification Factor (SIF) and flexibility, which we have attempted to compare results of B31 result against B31J. Our main aim is to solve all the forces in component which are above allowable limit against standard load condition such as Sustained, Operation, Hydro-static and other Experimental cases.

**Keywords-** Stress Analysis, Flexibility, Codes, Standards, B31J, SIF Calculations, Stress Analysis Report.

## I. INTRODUCTION

One of the major task in industry is the transportation of fluid from one location to another the piping system not only involves pipes but also fittings. According to Markl's (1940-1950) who was a scientist done different experiments on piping system and he observed that major failure are occurred at fittings such as elbow, tee, reducer, etc. in the piping system due to the varying cross section of the fittings. Our main focus on analysis at Tee Junction.

## II. INDENTATIONS AND EQUATIONS

Abbreviations:

Mean radius of matching pipe (r1)

Flexibility characteristics (h)

Section modulus of pipe (Z)

Stress intensification factor (SIF)

Header outside diameter (D)

Branch outside diameter (Db)

Header nominal thickness (th)

Branch nominal thickness: (tb)

Flexibility Factor (k)

Outer Diameter (r2)

Stress intensification factor out plane (io)

Stress intensification factor In plane (ii)

$$\text{SIF (io)} = \frac{0.9}{h^{2/3}} \quad (1)$$

$$\text{SIF (ii)} = \frac{3}{4} \text{io} + \frac{1}{4} \quad (2)$$

$$k = 1 \quad (3)$$

$$h = \frac{T}{r^2} \quad (4)$$

## III. METHODOLOGY

By using alternative method the stated problem can be resolved by the following technique:-

Solution I - By changing routing of the piping, i.e. by providing the flexibility of pipe the problem can be resolved.

Solution II - By changing the SIF (Stress Intensification Factor), the problem can be resolved

After analyzing the system in CAESAR software we found out failure region and values of various stresses acting on it. Occurrence of failure near the welded tee section of connected pipes, as in fig which causes oil leakage which effect on production system. Continuous pressurized fluid on Tee section generates back pressure on the walls which affect thickness of pipe, stresses beyond elastic property it result into failure at joint section.

As Shown in below figure the piping system get failed at the Tee junction:-

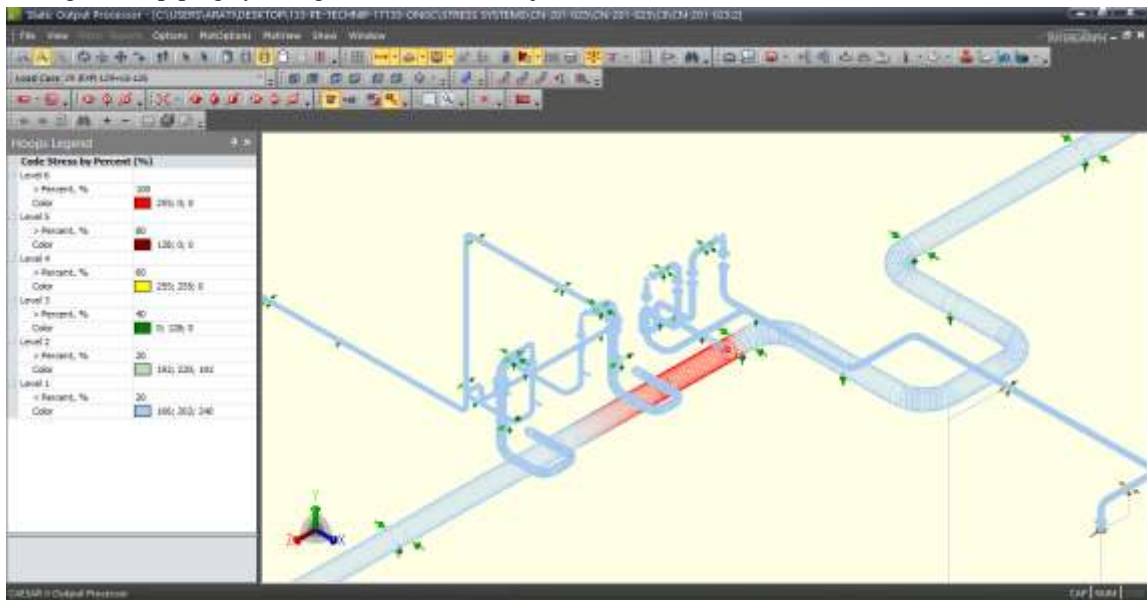


Fig -1 System Which Get Failed

As Shown in below figure the piping system get resolved at the Tee junction by modification in routing:-

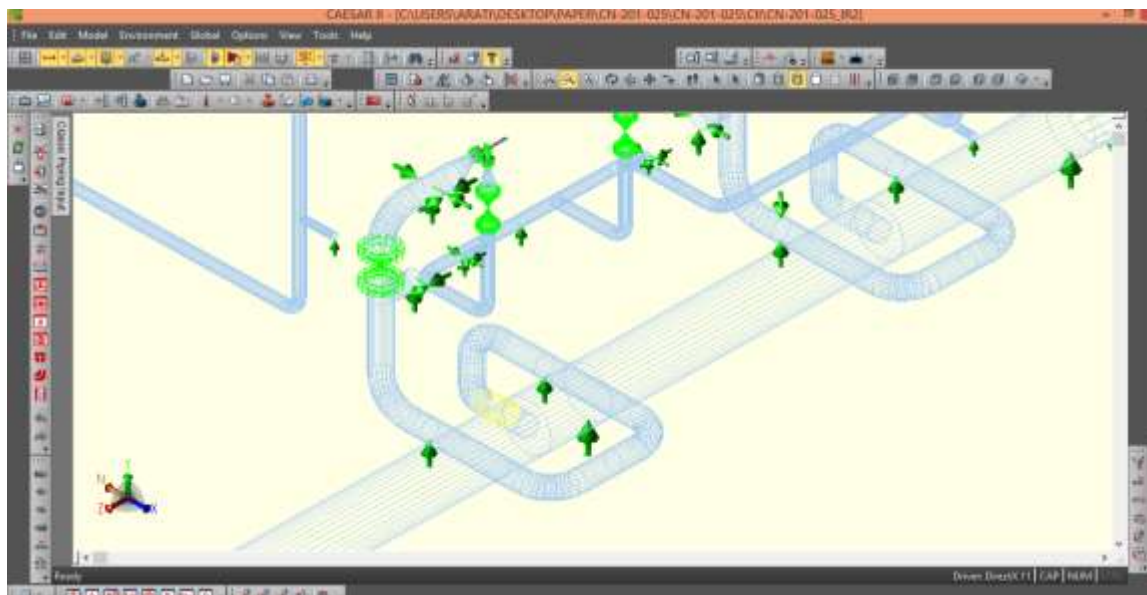


Fig -2 System which get resolved

SIF calculation example:-

For different types of fittings ASME B31 code gives formulae to calculate h, k and SIFs.

Assume an Unreinforced fabricated Tee junction having given data

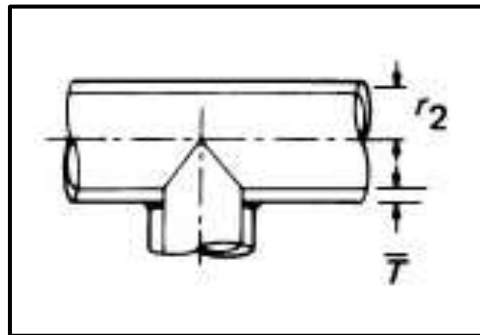
Header outside diameter:  $D = 12.75''$

Header nominal thickness:  $t_h = 0.375''$

Branch outside diameter:  $D_b = 10.625''$

Branch nominal thickness:  $t_b = 0.365''$

Mean radius of header:  $r_2 = 6.1875''$



**Fig -3 Tee Section**

Flexibility characteristics:  $h = T / r_2 = 0.375 / 6.1875 = 0.06$

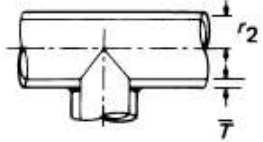
Flexibility factor:  $k = 1$  (as per ASME B31, Appendix D)

Out-plane SIF:  $i_o = 0.9 / h^{2/3} = 0.9 / 0.062^{2/3} = 0.9 / 0.154 = 5.83$  (as per ASME B31, Appendix D)

In-plane SIF:  $i_i = 0.75 * i_o + 1/4 = 0.75 * 5.83 + 0.25 = 4.62$

The above results have compared with CAESAR II output and found consistent.

Node	Axial Stress lb/sq. in	Bending Stress lb/sq. in	Torsion Stress lb/sq. in	Hoop Stress lb/sq. in	Max. Stress Intensity lb/sq. in	SIF In Plane	SIF Out Plane	Code Stress lb/sq. in	Allowable Stress lb/sq. in	Ratio %	Piping Code
20	-119.7	1005.1	0.0	0.0	1124.7	1.000	1.000	1005.1	49125.6	2.0	B31.3
30	-119.7	10716.9	0.0	0.0	10836.5	4.625	5.833	10716.9	45002.4	23.8	B31.3
30	0.0	0.0	0.0	0.0	0.0	4.625	5.833	0.0	42169.6	0.0	B31.3
40	0.0	0.0	0.0	0.0	0.0	1.000	1.000	0.0	49054.8	0.0	B31.3

Description	Flexibility Factor, $k$	Stress Intensification Factor		Flexibility Characteristic, $h$	Sketch
		Out-of-Plane, $i_o$	In-Plane, $i_i$		
Unreinforced fabricated tee	1	$\frac{0.9}{h^{2/3}}$	$\frac{3}{4}i_o + \frac{1}{4}$	$\frac{T}{r_2}$	

**Fig – 4 Formulae for Tee Section**

#### IV. CONCLUSION

There are two methods by which we resolve the issues at Tee junction as per follows:-

- 1) In first method we have changed the routing of the system to provide flexibility and resolved the stresses which cross the allowable limit as per codes and.
- 2) In second method we have calculated the SIF value and feed optimum value in the CAESAR II software at the Tee joint so that the system get resolved without changing the routing of piping system.

At first solution the piping system get resolved by changing the routing of piping system to provide sufficient flexibility. By changing the routing there are many ways of solutions but by selecting the optimum solution i.e. less material used, avoiding expansion joint, avoid hanger supports, etc. Generally, if any changes done in routing by the analyst then the analyst has to check the stress again of the piping system. From which the optimum design must be selected.

At second solution, the CAESAR II software take the same SIF values of fittings at the header & branch which is not required i.e. CAESAR II does not provide optimum SIF Values of header and branch. Later, CAESAR II introduce new part of it i.e. B31J which helps to calculate the optimum SIF values at different fittings. B31J calculate the different SIF values for header and branch respectively which enables to resolve the stress without changing the routing of piping system.

#### REFERENCES

- [1] Gaurav Bhende, Girish Tembhare on "Stress Intensification & Flexibility in Pipe Stress Analysis," International Journal of Modern Engineering Research (IJMER) Vol.3, Issue.3, May-June. 2013 pp-1324-1329
- [2] A.sivanagaraju, S.Krugon , Dr. M.Venkateswararao, on "Stress Analysis of Process Pipe Line Systems (ASME B 31.3) In a Plant Using Caesar-II," 2015 IJEDR Volume 3, Issue 3 ISSN: 2321-9939
- [3] Payal Sharma, Mohit Tiwari and Kamal Sharma on "Design and Analysis of a Process Plant Piping System," International Journal of Current Engineering and Technology. Special Issue-3, ISSN 2277 – 4106
- [4] "Piping Engineering," by IIT Bombay December 8 -21, 2004