BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Volumul 64 (68), Numărul 1, 2018
Secţia
CONSTRUCŢII DE MAŞINI

CAD-FEA STUDY OF A PIPE T SHAPE WITH REDUCTIONS

BY

MIHAIL AIGNĂTOAIE*

"Gheorghe Asachi" Technical University of Iaşi, Romania,
Faculty of Mechanical Engineering

Received: January 8, 2018
Accepted for publication: June 26, 2018

Abstract. The usual structure of a piping system includes pipe T shapes. The use of reductions could be imposed by functional criteria of the installations. Any pipe T shape represents a stress concentration area. The safety measures impose the necessity to evaluate the influence of various shapes on stress concentration.

The paper presents a CAD (Computer Aided Design) and FEA (Finite Element Analysis) study on a pipe T shape with reductions, considering an interior pressure applied in linear elastic static conditions. The study was performed within Salome-Meca (for the geometry definition and the FEA pre/post processing)) and Code Aster (for the FEA processing). Both packages are developed by EDF (Electricité de France), France. A comparison of the von Mises stress distribution is made in order to analyse the influence of various shapes of reductions on the stress concentration in the studied models.

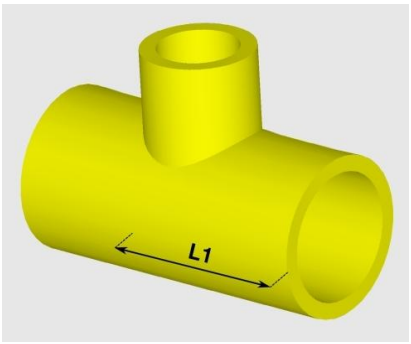
Keywords: FEA; Salome-Meca; Stress concentration; Pipe T Shape, Reductions.

1. Introduction

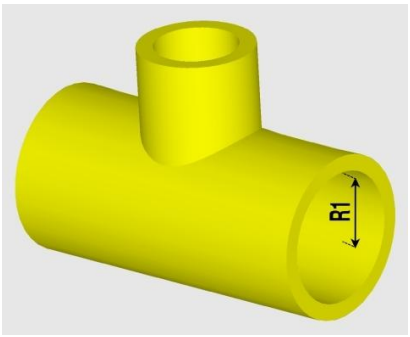
A piping system use frequently T shapes. Such elements include stress concentration areas. For safety reasons, efforts are made in order to evaluate and

*Corresponding author; *e-mail*: maignato@tuiasi.ro

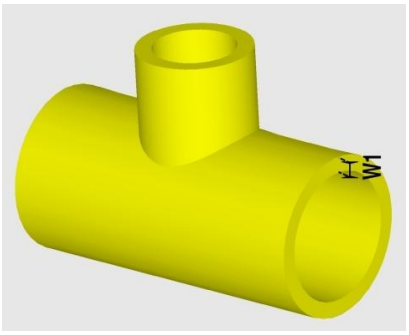
reduce the stress gradient. There are no theoretical solutions or analytical calculus procedures to completely determine the stress level (Boresi *et al*., 2003; Moss, 2004; Young *et al*., 2002).



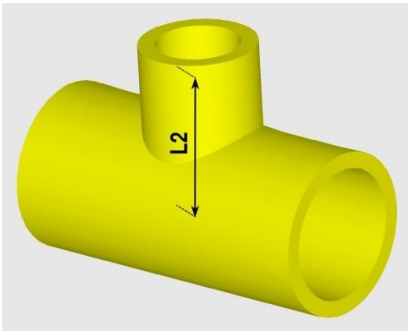
L1=480mm:Length of the main pipe.



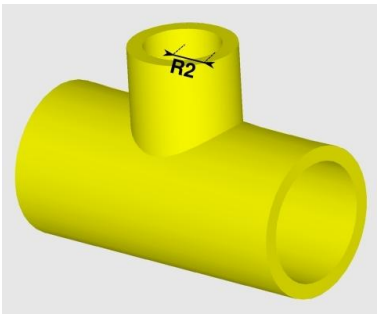
R1=160mm:Radius of the main pipe.



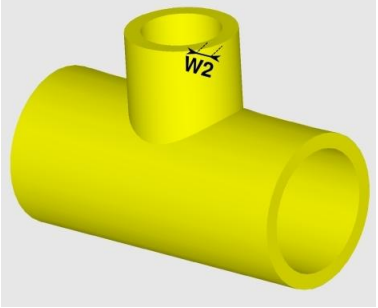
W1=20mm:Thickness of the main pipe.



L2= 480mm:Length of the incident pipe.



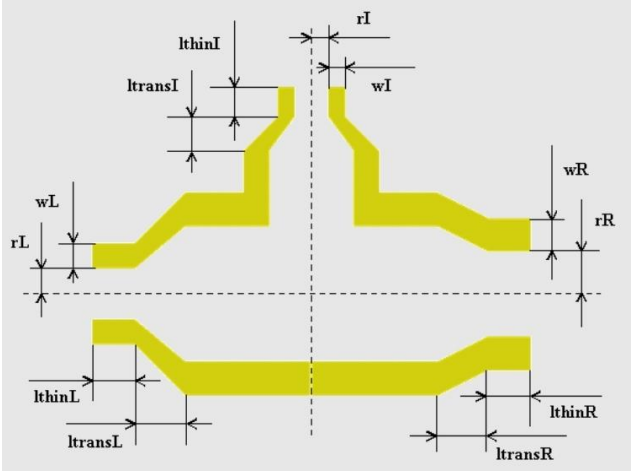
R2=100mm:Radius of the incident pipe.



W2=20mm:Thickness of the incident pipe.

Fig. 1 − Geometrical parameters defining the T shape.

The practical alternative is the use of CAD, Computer Aided Design and FEA, Finite Element Analysis. Previous studies in this field have considered the influence of the CHAMFER and FILLET shapes (Aignătoaie, 2016a; Aignătoaie, 2016b).



- **rL**=80mm- internal radius of left thickness reduction.
- **wL**=20mm - width of left thickness reduction.
- **ltransL** - length of left transition part.
- **lthinL** - length of left thin part.
- **rR=80mm**- internal radius of right thickness reduction.
- **wR**=20mm - width of right thickness reduction.
- **ltransR** - length of right transition part.
- **lthinR** - length of right thin part.
- **rI**=50mm- internal radius of incident thickness reduction.
- **wI**=20mm - width of incident thickness reduction.
- **ltransI** - length of incident transition part.
- **lthinI** - length of incident thin part.

Fig. 2 − Geometrical parameters defining the reductions in the T shape.

The paper considers several study cases of pipe T shape structures with reductions.

2. The CAD-FEA Study

The CAD-FEA studies were performed by use of the open source packages Salome-Meca (for the geometry definition and FEA pre/post processing) and Code-Aster (for the FEA processing). Salome-Meca and Code-Aster are developed by EDF, France.

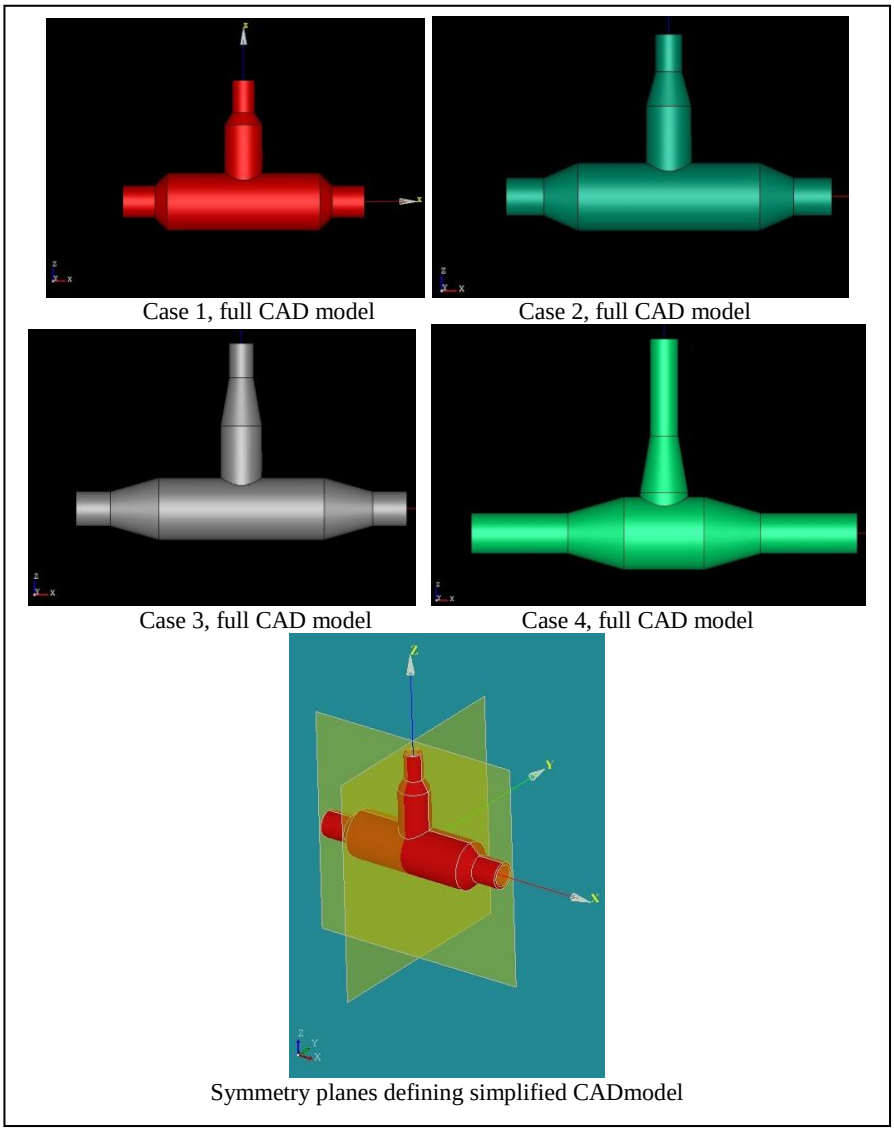
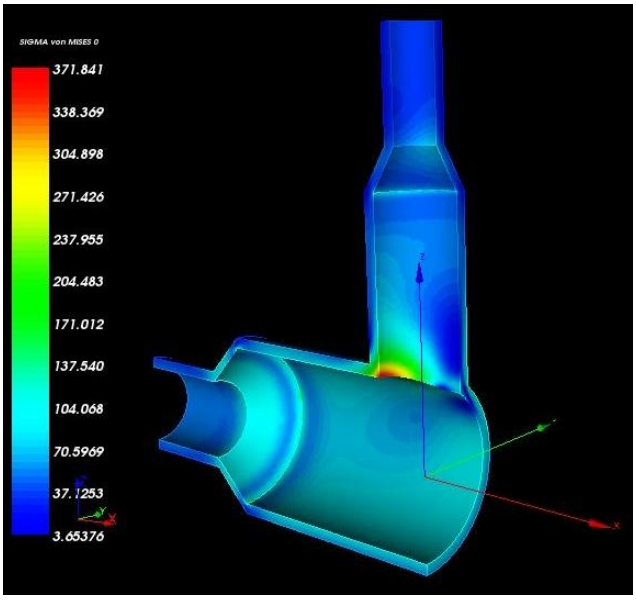
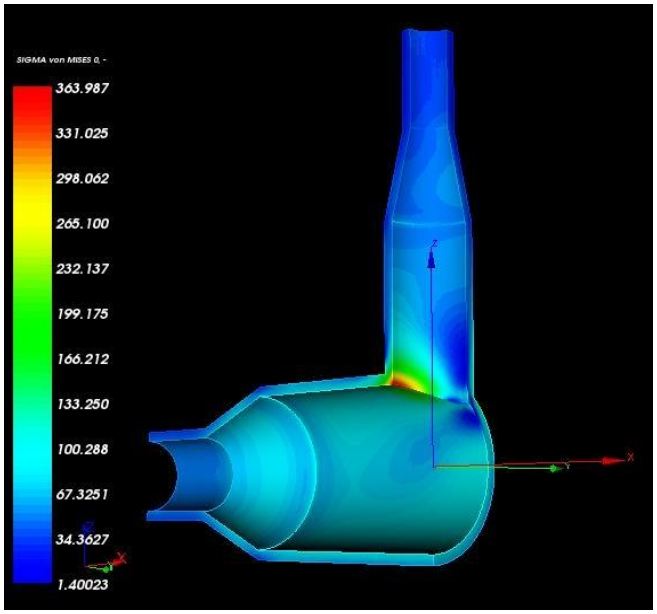


Fig. 3 − Full CAD models and the definition of the geometry for the simplified FEA models.

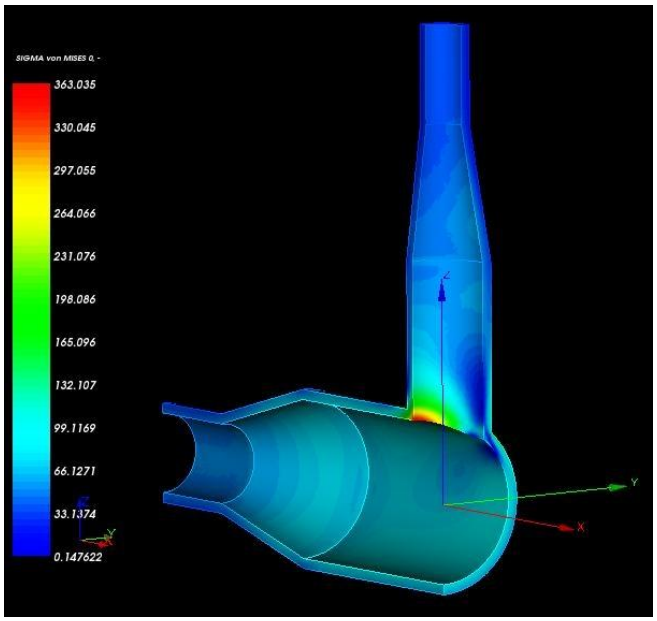


Case 1: $\sigma_{\text{von Mises}}$, [MPa]

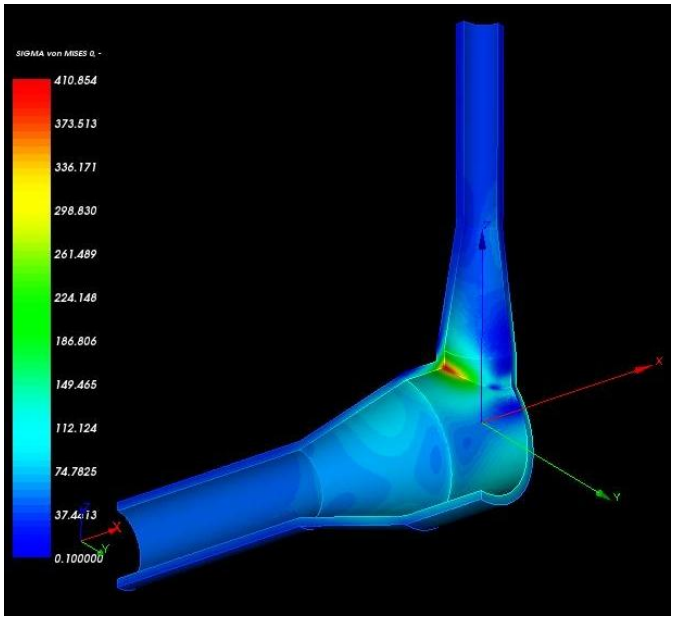


Case 2: $\sigma_{\text{von Mises}}$, [MPa]

Fig. 4 − $\sigma_{\text{von Mises}}$ distribution in study cases 1 and 2, [MPa].



Case 3: $\sigma_{\text{von Mises}}$, [MPa]



Case 4: $\sigma_{\text{von Mises}}$, [MPa]

Fig. 5 − $\sigma_{\text{von Mises}}$ distribution in study cases 3 and 4, [MPa].

Table 1
Basic Parameters of the CAD-FEA Study

Case Study	Case 1	Case 2	Case 3	Case 4
Common geometrical parameters (Figs. 1 and 2) : ltransL= ltransR=ltransI= lthinI=lthinR=lthinI	80 200	180 200	280 200	200 280
Nr. of Nodes	189213	234724	236961	251395
Nr. of Elements TETRA10 (Quadratic Tetrahedrons)	105744	131230	131895	142285
Total Nr. of Equations	591773	728490	735737	779055
Maximal value of SIGMA von Mises, [MPa]	371.84	363.99	363.035	410.85

The basic geometry of the study cases is described in Figs. 1-2 and Table 1. Each full CAD model has 2 symmetry planes, Fig. 3. The FEA study considered only simplified models representing a quarter of the initial full model, Fig. 3. The T shaped pipes are manufactured from an usual steel ($E=2.1\cdot10^5$ MPa, $\nu= 0.3$). The load is an interior pressure p= 10 MPa, constant during FEA simulation.

The most important parameters of the CAD-FEA studies are included in the Table 1.

3. Discussions and Conclusions

– The facilities for designing T shaped pipes available within Salome_Meca 8.2 make possible a convenient design and test of complex circuits of pipes by use of FEA. The user has a "Preview" option for the shapes of the T shape pipe chosen at a certain moment.

– The shape of the reduction, as defined by the parameters ltransL**,** ltransR**,** ltransI**,** Fig. 2, reduces the stress concentration phenomenon, Figs. 4 and 5. However the efficiency of this solution is limited after a certain value, Case 3.

– The positioning of the reduction very close to the intersection between the main and incident pipe is not favourable for the level of the stress concentration, case 4, Fig. 5.

– Future studies could determine the evolution in time of the stresses caused by a dynamic pressure applied with various rates.

REFERENCES

Aignătoaie M., *CAD-FEA Study on the Influence of Chamfer on Stress Concentration in a Pipe T Shape*, Bul. Inst. Polit. Iaşi, **LXII (LXVI)**, *4*, s. Constr. Maş., 19-26 (2016a).

Aignătoaie M., *CAD- FEA Study on the Influence of Fillet on Stress Concentration in a Pipe T Shape*, Bul. Inst. Polit. Iaşi, **LXII (LXVI)**, *4*, s. Constr. Maş., 27-34, (2016b).

Boresi Arthur P., Schmidt Richard J., *Advanced Mechanics of Materials*, 4th Ed., John Wiley & Sons, Inc., Hoboken, 389-399, 502-542, 2003.

Moss Dennis R., *Pressure Vessel Design Manual: Illustrated Procedures for Solving Major Pressure*, 3rd Ed., Gulf Professional Publishing, Burlington, USA, 1-7, 255, 2004.

Young Warren C., Budynas Richard G., *Roark's Formulas for Stress and Strain*, 7th Ed., McGraw-Hill, New York, 73-79, 553-688, 771-797, 2002.

*** CAELINUX, www.caelinux.com, accessed 21.12.2016.

*** CODEASTER, www.code-aster.com, accessed 21.12.2016.

*** SALOME, www.salome-platform.com, accessed 21.12.2016.

STUDIU CAD-FEA AL UNEI STRUCTURI DE ȚEVI RAMIFICATE ÎN T CU REDUCȚII

(Rezumat)

Structura uzuală a unui sistem de conducte include şi ţevi ramificate în T. În unele cazuri pot exista condiţii de funcţionare a instalaţiei care să impună utilizarea unor ţevi cu reducţie. Orice ansamblu de ţevi ramificat în T reprezintă o zonă de concentrare a tensiunilor. Condiţiile de siguranţă impun evaluarea influenţei unor factori constructivi asupra fenomenului de concentrare a tensiunilor.

Lucrarea prezintă un studiu CAD (Computer Aided Design, Proiectare Asistată de Calculator) şi FEA (Finite Element Analysis, Analiză cu Elemente Finite) a unei ţevi ramificate în T cu reducţii, considerând ca sarcină o presiune interioară aplicată în domeniul linear elastic static. Studiul a fost realizat cu ajutorul pachetelor Salome-Meca (pentru definirea geometriei, şi pre/post procesare FEA) şi Code-Aster (pentru procesare FEA). Ambele pachete sunt dezvoltate de EDF, Franţa.

Este prezentată o comparaţie (pe baza distribuţiei tensiunilor von Mises) pentru a pune în evidenţă influenţa diferitelor forme de reducţii asupra fenomenului de concentrare a tensiunilor.