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FEA STUDY ON THE INFLUENCE OF CHAMFER ON NATURAL MODES OF VIBRATION OF A PIPE T SHAPE

BY

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Abstract. The pipeline circuits are components frequently used in many applications in mechanical engineering. For the case of pipe T shapes the stress concentration is present. The phenomenon is reduced by use of chamfer shape in the area of intersection between a main pipe and an incident pipe. For a specific application, previous FEA based studies have evaluated the possibilities to reduce the stress concentration. The paper presents a FEA study of the influence of chamfer on the natural modes of vibration performed on the same CAD models. The CAD and FEA modeling of the problem was performed by use of Salome-Meca, property of EDF-France, as part of the open-source package CAELINUX. A comparison is made, for the first 12 natural frequencies between the standard model (a T-shape pipe without chamfer) and the same geometry with chamfer in the stress concentration area.

Keywords: FEA; CAELINUX; Vibrations; Chamfer; Pipe T Shape.

1. Introduction

A theoretical design of pipes could be based on analytical formulas from the theory of thick-walled vessels (Boresi and Schmidt, 2003). Some

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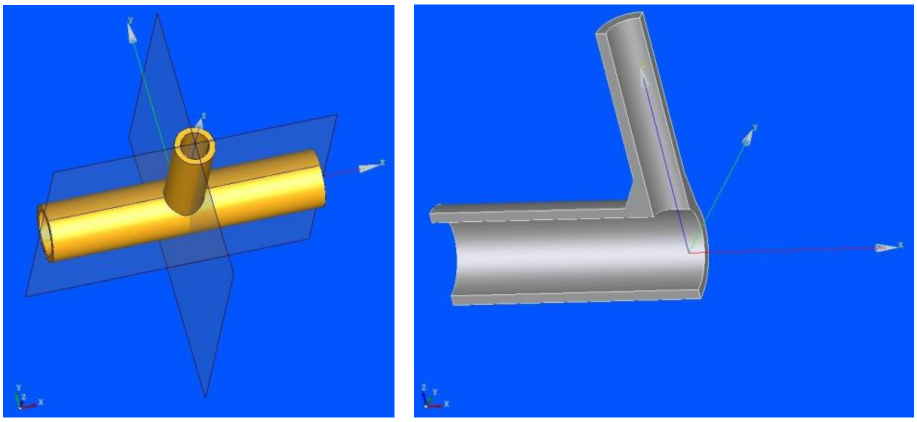
methods, (Moss, 2004), using the ASME Code, Section VIII, Division 1 recommend specific rules that does not require a complete evaluation of the stresses distribution. The design of piping systems is very important for many industrial projects, especially if the shape of pipes is complex. In some cases the piping systems could have complex shapes, for example the T shape pipes. In the preliminary phase of the design the simulation of the behavior of the system could be performed by use of FEA. Previous studies (Aignătoaie, 2016) have studied the influence of chamfer shape on the stress concentration in the vicinity of the area of intersection between a main pipe and an incident pipe with rectangular axes. The basic aspects for the study of the behavior of systems subjected to vibrations are defined by (Piersol and Paez, 2010). The paper presents a FEA study, by use of Salome-Meca, (*** *CAELINUX*, 2019), concerning the influence of the chamfer on the natural modes of vibration of a T shape pipe.

2. The FEA Study

The study of the natural modes of vibration was performed on the same CAD models previously used for analyzing the stress concentration phenomenon, (Aignătoaie, 2016), presented in Fig. 1*a*.



a *b*

Fig. 1 – CAD models: *a* – complete model; *b* – simplified model with chamfer.

Two basic CAD models were considered:

1. Standard model (the T-shape pipe without chamfer).

2. Chamfer H=60; W=30 model (the same T-shape pipe as above with the chamfer parameters: H=60 mm, height along the incident pipe and W=30 mm, the width along the main pipe :).

The geometry has two symmetry planes. That made possible a FEA study on a simplified model, Fig. 1*b*.

The material of the models was considered the AISI 1010 steel with the following characteristics: modulus of elasticity: E=205 GPa, Poisson’s ratio: ν=0.29, density: ρ=7.87 g/cc.

The basic parameters for the FEA study are presented in Table 1.

Table 1
Basic Parameters of the FEA Modelling

Study case	Finite Elements TETRA10 [Quadratic tetrahedrons]	Nodes	DOFs
1. Standard model	136567	237371	740289
2. Chamfer H=60; W=30 model	144332	249087	776285

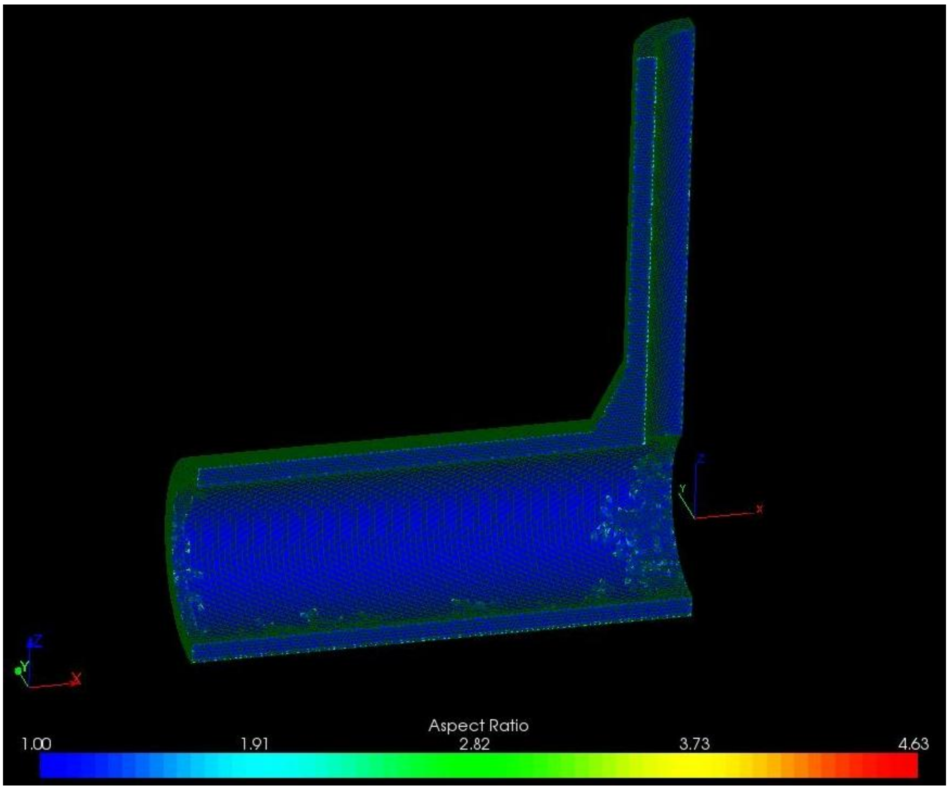


Fig. 2 – The mesh checked with the Aspect Ratio Face option.

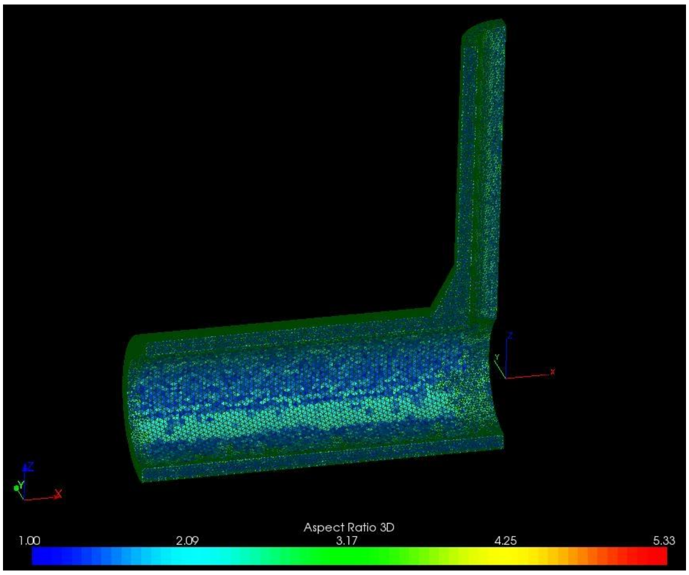


Fig. 3 – The mesh checked with the Aspect Ratio 3-D option.

The mesh quality could be checked in Salome-Meca considering several tools like aspect ratio 2-D face, Fig. 2 and aspect ratio 3-D, Fig. 3.

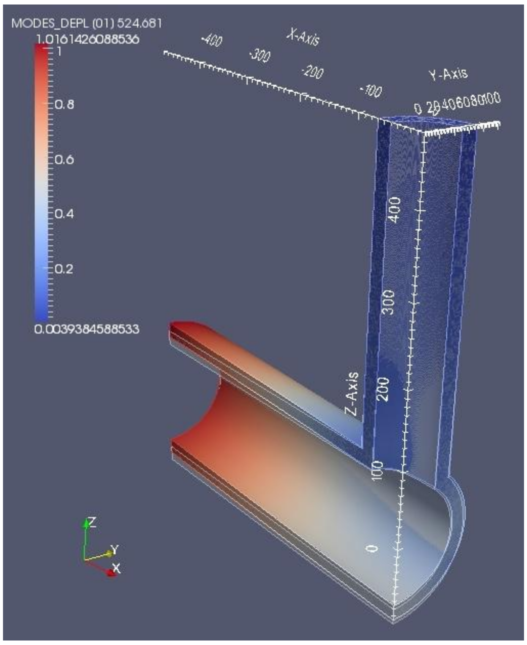


Fig. 4 – Standard model: mode shape 1.

The FEA study determined the first 12 natural modes of vibration for all the considered models: -1. Standard model-2. Chamfer H=60; W=30 model.

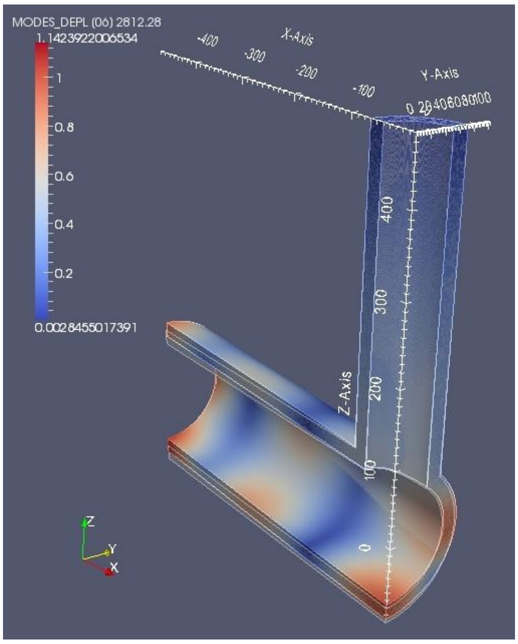


Fig. 5 – Standard model, mode shape 6.

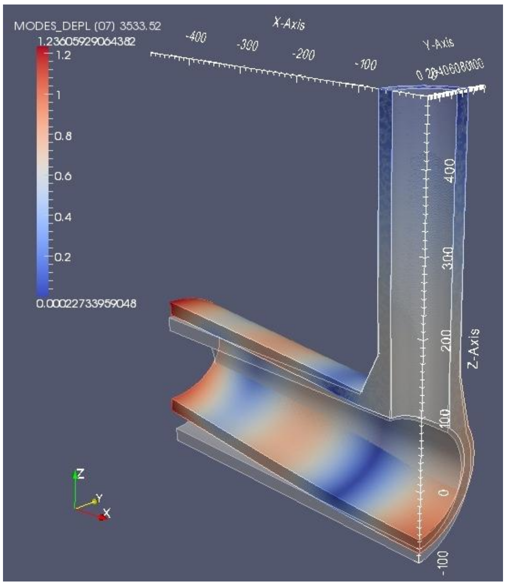


Fig. 6 – Chamfer H=60; W=30 model, mode shape 7.

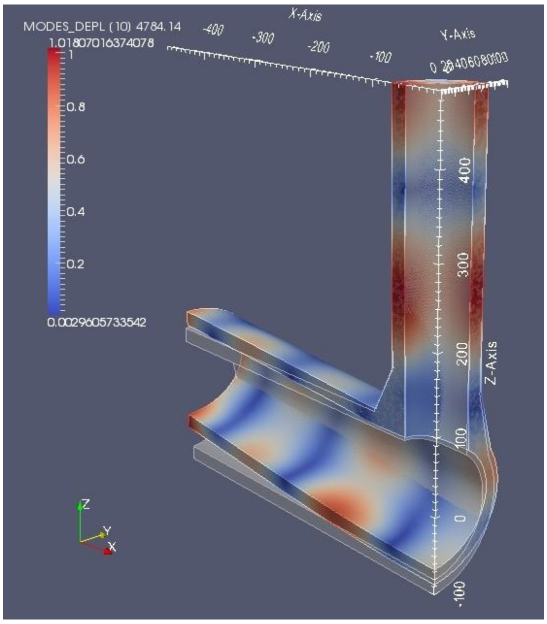


Fig. 7 – Chamfer H=60; W=30 model, mode shape 10.

Figs. 4 and 5 presents a selection of the mode shapes of the standard model. Figs. 6 and 7 presents examples of mode shapes determined for the chamfer H=60; W=30 model. The non-deformed geometry, with a significant level of transparency, is superimposed in the pictures.

Table 2

The Influence of the Chamfer Shape on the Frequencies of the Natural Modes of Vibration

Mode of vibration number	Standard model Frequency [Hz]	Chamfer H=60; W=30 model Frequency [Hz]	Influence of chamfer shape [%]
1	524.681	597.983	13.97077
2	1291.42	1416.46	9.682365
3	1628.66	1831.63	12.46239
4	2062.67	2232.11	8.214596
5	2531.02	2615.51	3.33818
6	2812.28	3009.94	7.028461
7	3516.64	3533.52	0.480004
8	3544.65	3868.93	9.148435
9	4144.41	4563.33	10.10807
10	4335.57	4784.14	10.34628
11	4375.55	4950.72	13.14509
12	4615.73	5227.51	13.25424

3. Discussions and Conclusions

The influence of the chamfer on the mode shapes of the T shape pipe is presented in Table 2. Except the mode shape 7 and partially mode 5, all frequencies were significantly modified with approximate 10%.

The chamfer option reduces the stress concentration with approximate 13.83%, (Aignătoaie, 2016), and make possible, if needed, to increase the values of mode shapes frequencies with a comparable percent.

The values of the natural frequencies included in Table 2 could be used in future research on the same structure subjected to dynamic loads.

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*** *CAELINUX*, www.caelinux.com, accessed 10.01.2019.

STUDIU FEA AL INFLUENȚEI FORMEI CHAMFER ASUPRA MODURILOR PROPRII DE VIBRAŢIE PENTRU O ŢEAVĂ RAMIFICATĂ ÎN T

(Rezumat)

Circuitele de conducte sunt componente utilizate frecvent în multe aplicaţii din Ingineria mecanică. În cazul racordurilor în T se produce o concentrare a tensiunilor. Fenomenul poate fi redus prin utilizarea formei chamfer în zona de intersecţie dintre ţeava principală şi ţeava incidentă. Pentru o aplicaţie concretă, studii FEA anterioare au evaluat nivelul de reducere a concentrării tensiunilor. Lucrarea prezintă un studiu FEA al influenţei folosirii formei chamfer asupra modurilor proprii de vibraţie, pentru cazul aceloraşi modele CAD. Modelarea CAD şi FEA a problemelor s-a realizat cu ajutorul pachetului open-source Salome-Meca, dezvoltat de EDF-Franţa. Sunt comparate frecvenţele corespunzătoare primelor 12 moduri proprii de vibraţie pentru modelul standard (racord în T fără forma chamfer) şi aceeaşi structură cu chamfer în zona de concentrare a tensiunilor.