Vibration Analysis of Peristaltic Pump Using FEA and FFT Analyzer

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Abstract: The number of positive displacement pump is used now days. Out of them one is peristaltic pump. Peristaltic pump can use to pump the variety of fluids. Pump consists of circular casing generally made from polymer rubber which is capable to support the fluid pressure and roller pressure. Inside the casing polymer rubber tube fitted along inside circumference of a casing having circular cross-section. The number of rotating roller inside the casing makes the tube to get compressed. There is contact between tube and rollers cause a friction. So it is necessary to find out the design parameter and vibration of the pump arises due to tube.

Vibration in a system causes due to unbalance mass or displacement of mass having a motion. So study is necessary to find out solution to minimize the vibration of the pump. Hence study involves finding out the natural frequency and mode shapes of a pump using 'ANSYS' and experiment. In this paper we did four iteration for peristaltic pump tubing to check the vibration. Further it is validate using FFT analyzer. Finally concluded about the tube vibration and about its value and which one is superior

Index Terms - **Peristaltic pumps, tubing, FEA, FFT, natural frequency.**

I. INTRODUCTION

A pump is a device used to move fluids, such as liquids, gases or slurries. A pump displaces a volume by physical or mechanical action. Pump is the oldest fluid-energy-transfer device known. Pumps are used in all types of industries and domestic purposes. A Peristaltic Pump is a type of a Positive Displacement Pump. It is often used to pump different types of fluids. The principle of positive displacement uses a mechanism to repeatedly expand a cavity so as to allow fluids to flow into the cavity, and then seal that cavity. The fluid then moves forward. The only pumping element of peristaltic pump is flexible tube. The pump works by squeezing the tube with rollers or shoes. This means that pump can run dry, self-prime and handle viscous or abrasive liquids, plus, as the tube is one complete unit, there are no seals. This makes the pump leak free and hygienic.

This is a micro pump used in pharmaceutical industry, Blood dialysis of human body so it is a vital device wherever it is used, Peristaltic pump cam pump the liquids in any direction it does not has any fixed input and output, so we can pump the liquids in any direction by changing the rotating direction of rollers namely clockwise or anticlockwise. [4]Here we are going to study the causes of vibration and vibrational analysis using FEA. In this for experiment we have taken four flexible peristaltic tubing having different material namely Flexible PVC, Silicon rubber, Thermoplastic elastomer and Viton rubber. Out of which we have to find out which tube material has a minimum resonance frequency and hats will be the conclusion, first of all we did the study about the vibration and checked the causes of vibration. After that we did the CAD model and applying boundary conditions. Next by giving excitation to the peristaltic pump we will get the natural frequencies for four different materials.

II. LITERATURE SURVEY

DeBakey invented the roller pump in heart-lung machine during his student years in 1932. This device, which rhythmically propels fluid through a flexible tube, would later become a crucial part of the heart-lung machine used during open heart surgery. Its ability to replicate the rhythmic pulsing of the human heart earned it the name "peristaltic pump."

Mr. Shakil H. Chaudhary [3]in their overview of design, optimization and vibrational analysis of peristaltic pump using FEA said that many reasons about vibrational analysis and he stated that optimized ways to avoid the vibration in peristaltic pump. His Study also said that suitable mechanism so that the life of tube may increase. Literature survey about peristaltic pump also includes dynamic behavior of bearing of peristaltic pump. Massimo Scali (1992) used finite element analysis to study the behavior vertical pump under vibration. A finite element model was created to represent the actual vertical pump. The pump was assumed to be running at critical speed. The modal analysis was initially done to find the natural frequency of the pump and mode shapes of the pump. The design was then modified to shift the natural frequency away from the operating g frequency. The analysis of the modified design was done using finite element analysis. The pump was assumed to be running at critical speed. The modal analysis was initially done to find the natural frequency of the pump and mode shapes of the pump. The design was then modified to shift the natural frequency away from the operating g frequency.

E. N. Aitavade in their paper said that Basic Shape for rotary peristaltic pump Rotary peristaltic pump have pump case, hose, rotor, shoe and motor. The Pump case has rotor that lay down at shaft that support by it bearing. Normally two shoes will put at

rotor Rotary peristaltic pump have two flange. This flange will be connecting input fluid and output. Hoses are pump element that be found at peristaltic pump, which rotor and shoe is use to pressed hose and will be have vacuum to pulling fluid to enter the hose. Rotary peristaltic pump is different from the linear type where the rotary type used motor to rotate the shaft linear type used cam to control the motion of shaft. The rotor is attached to the shaft that connected to the motor. End of strip rotor was pressed the hose and the vacuum is form to produce attraction force.

III. PROBLEM STATEMENT

Study the failure of peristaltic pump due to vibration. Enhance the working efficiency of the peristaltic pump by reducing the vibration. Hence to study the design parameter and analyse the vibration using FEA. Perform the different iteration by changing the material of the tube. Validate it by FFT analyser as an experiment.

IV. OBJECTIVES

i. Perform different iteration by changing the material of the tube and find the optimum vibration.
ii. Analyse the different mode shapes by using FEA.
iii. Study the reasons of vibration caused in the existing design of peristaltic pump.
iv. Analyse the different parameter of pump.
v. Validate the FEA result with FFT analyser.
vi. Find out values of vibration and suggest best tube for a peristaltic pump.

V. THEORETICAL STUDY OF VIBRATION

A. *Vibration causes a number of harmful effects* [2]:

(a) Excessive bearings wear.

(b) Cracks Formation in machines,

(c) Loosening of fasteners in mechanical systems.

(d) Structural and mechanical failures in machines and buildings.

(e) Frequent and costly maintenance of machines.

(F) Vibration also causes a pain, discomfort and reduction in working efficiency.

B. *vibration control*

The vibration can sometimes be eliminated on the basis of theoretical analysis. However, in eliminating the vibration may be too high. Therefore, a designer must compromise the manufacturing costs involved between an acceptable amount of vibration and a reasonable manufacturing cost. The following steps may be taken to control vibrations:

(a) A suitable modification of parameters may also reduce the excitation level. The system parameters namely inertia, stiffness and damping are suitably chosen or modified to reduce the response to a given excitation.

(b) The first group of methods attempts to reduce the excitation level at the source. The balancing of inertial forces, smoothening of fluid flows and proper lubrication at joints are effective methods and should be applied whenever possible.

(c) In this method, transmission of path of vibration is modified. It is popularly known as vibration isolation.

VI. MODAL ANALYSIS USING ANSYS

FEA Analysis of pump

Here we have done modal analysis of a peristaltic pump for four material of tube namely flexible PVC, Silicon rubber, Thermoplastic elastomer and Viton rubber. [5]

Modal analysis of Peristaltic pump (For Flexible PVC tube)
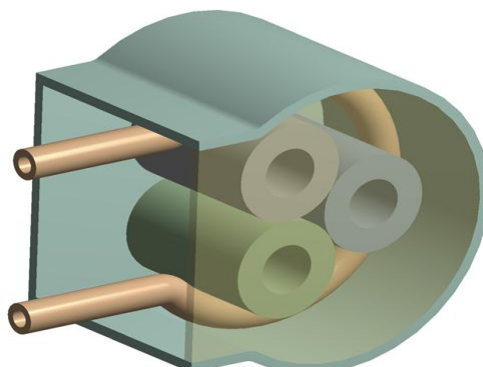
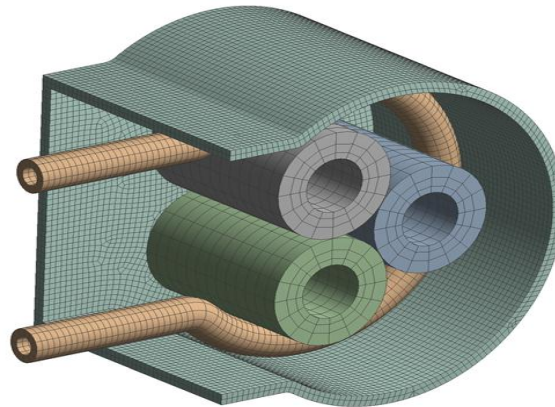Fig. 6.1: shows CAD model of Peristaltic pump assembly

Fig. 6.2: Meshed model of Peristaltic pump assembly

Below is the six mode shape of flexible PVC material tube. We are find at which assembly vibrates with maximum amplitude. Frequencies of an assembly are given in Hz.
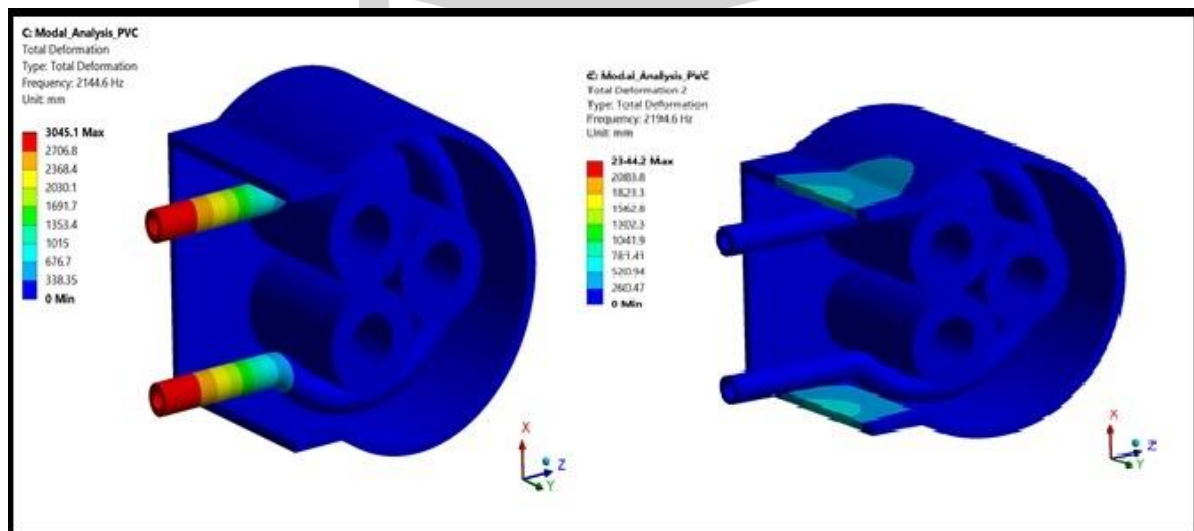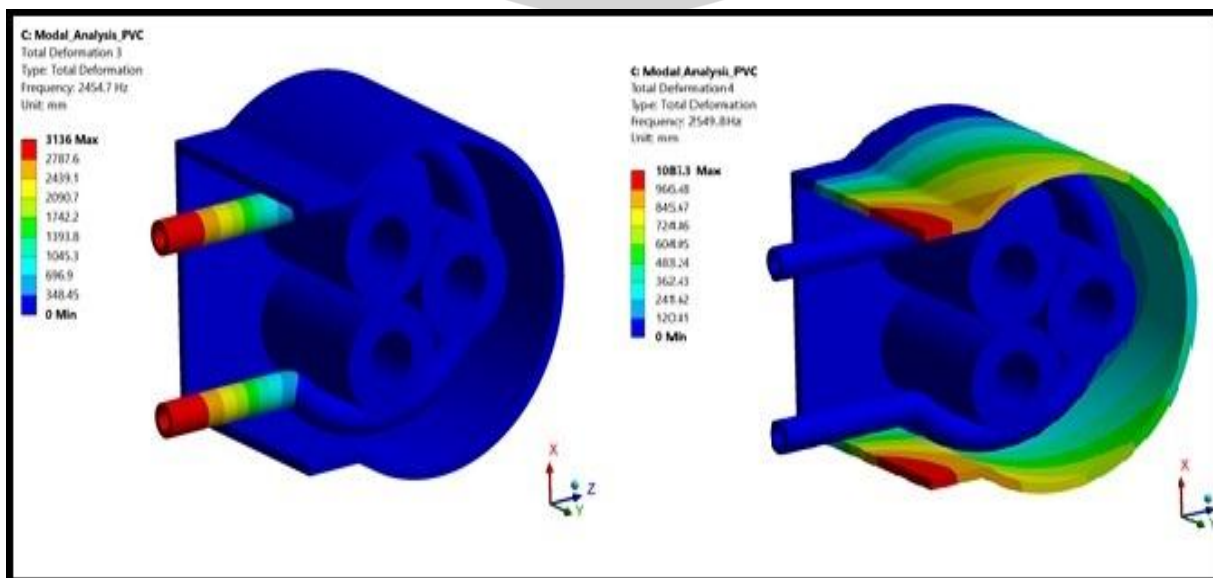

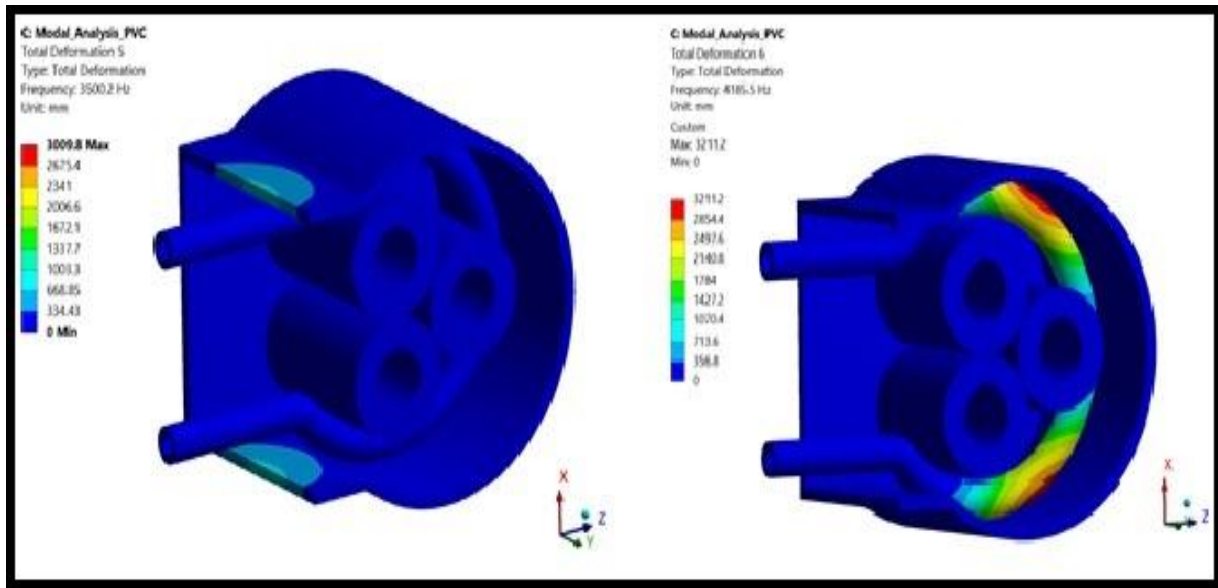Fig. 6.3: Mode Shape No.1and 2

Fig. 6.4: Mode Shape No.3 and 4

Fig. 6.5: Mode Shape No.5 and 6

Table below indicates six mode shapes of Peristaltic Pump assembly and their respective frequencies for peristaltic pump using flexible PVC tube.

Table No.6.1

Flexible PVC Material		
Sr. No.	Mode Shape	Frequency (Hz)
1	1	2144.3
2	2	2194.6
3	3	2454.3
4	4	2549.8
5	5	3500.2
6	6	4185.5

Here it not possible to show each and every mode shapes for peristaltic pump tube hence directly values are arranged in the tables. Following table shows the different mode shapes and having respective frequencies for the different tube namely
(a) Silicon rubber
(b) Thermoplastic elastomer (TPE)
(c) Viton rubber.

Table No. 6.2

Sr. No.	Types of Tubes	Mode shape No. 1	Mode shape No. 2	Mode shape No. 3	Mode shape No. 4	Mode shape No. 5	Mode shape No. 6
		Frequency (Hz)					
1	Silicon rubber	136.9	155.33	268.6	277.23	487.02	527.33
2	Thermoplastic elastomer (TPE)	1800.7	2062.9	2194.6	2549.8	3500.2	3510.7

3	Viton rubber.	129.02	203.13	351.21	362.52	636.2	689.5

VII. ANALYSIS USING FFT

After doing no. of experiment using FFT analyser on peristaltic pump for their no. of tube I get following results. During the experiment I connected the probe of the FFT analyser to the peristaltic pump. In the experiment I found three mode shapes and getting the near about same values of vibration with neglecting minor variation. Experimental obtained result are tabulated as follows,

Table No. 7.1

Sr. No.	Types of Tubes	Mode shape No. 1	Mode shape No. 2	Mode shape No. 3	Remark
		Frequency (Hz)			
1	Flexible PVC	1959	2283.4	2380.3	8.62% Variation
2	Silicon rubber	125.0	170.6	300.3	9.52% Variation
3	Thermoplastic elastomer (TPE)	1680.7	2264.9	2334.6	7.14 % Variation
4	Viton rubber.	142.02	220	380	9.15 % Variation

VIII. RESULT AND DISCUSSION

Initially we have taken a standard specimen of peristaltic pump which has a three rollers and single pass (single tube). By using the concept of reverse engineering we are measure the dimensions which has a pump then make model and analyses it on ANSYS. In that we got the different mode shapes for having different frequencies. Similarly we repeat same procedure to find out the different iteration for different tubes of a peristaltic pump. To validate the FEA result, further did analysis using the FFT analyser where we again find out the three modes shapes for four different tubes of peristaltic pump. In this three modes shapes we got three different frequencies which are similar to FEA result with minor variation.

Hence in this paper we have used number tube of peristaltic pump having a different material but according maximumresonance frequency we got Flexible PVC has maximum resonance frequency 2144.3Hz using FEA analysis and 1959 Hz using FFT analyser.The operating frequency 120Hz and the natural frequency 1959 Hz. Hence Operating frequency and natural frequency are too much apart from each other. Here we can conclude that flexible PVC is most suitable for peristaltic pump.

REFERENCES

[1]. Suhas R. Dhumal, S. S. Kadam, April 2012, Design and Development of Rotary Peristaltic Pump, Volume 2 No 4
[2]. Mohd Firdaus Bin Mansor, 14 November, 2008, Design and prototyping a peristaltic pump.
[3]. Chris Garneau, Kevin McNamara, Jae Chung, 3 May, 2006, Final Report Team D Peristaltic Pump ME 340.4.
[4]. Michael smith engineers ltd, "How a Peristaltic Pump works"
[5]. G. Böhme, Analysis of non-Newtonian effects in peristaltic pumping, Journal of Non-Newtonian Fluid Mechanics 201 (2013) 107–119
[6]. A.M. Provost, W.H. Schwarz, A theoretical study of viscous effects in peristaltic pumping, J. Fluid Mech. 279 (1994) 177–195.
[7]. E.F. Elshehawey, A.M.F. Sobh, Peristaltic viscoelastic fluid motion in a tube, Int. J. Math. Math. Sci. 26 (2001) 21–34.
[8]. A. Henrot, G. Villemin, An optimum design problem in magnetostatics, Mathematical Modelling and Numerical Analysis 36 (2) (2002) 223–239,

Internet
[1]. http://en.wikipedia.org/wiki/Peristaltic_pump
[2]. http://www.processsystems.saint-gobain.com/product_detail.aspx?id=258992
[3]. <http://www.ingentaconnect.com/content/klu/abme/1999/00000027/00000003/004832
[4]. <http://link.aip.org/link/?SMM/64/442/1>.