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VERTICAL TURBINE PUMP BASE STOOL MODAL ANALYSIS AND MODEL MODIFICATION

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ABSTRACT

The modal analysis of vertical turbine pump base stool is carried out using finite element analysis. Total six modes of vibration are found for this analysis. Pump operational frequency is 120 Hz which is very close to sixth natural frequency of base stool cylindrical shell. At the end of paper some structural modifications have suggested by providing longitudinal and circumferential ribs around the cylindrical base stool cylindrical shell to move natural frequency of base stool cylindrical shell away from pump operational frequency.

KEYWORDS: Base Stool Cylindrical Shell, Circumferential and Longitudinal Ribs, VTP (Vertical Turbine Pump)

INTRODUCTION

Vertical turbine pump base stool cylindrical shell is casing used to mount motor on it. Vibration is big issue for vertical turbine pump. The source of vibration in vertical turbine pump is mainly three types such as Mechanical causes, Hydraulic causes & Peripheral causes [1]. Vibration of pump can lead to mechanical loosening of parts, noise, fatigue failure and crack propagation etc.

These problem ultimately deteriorate functioning of vertical turbine pump functioning. Pump functioning and its behavior can be predicted by its dynamic analysis. The ability of the procedure to evaluate changes in system dynamics such as the addition of vibration control elements is demonstrated [2].

Resonance is major concern in vibration. When the one of natural frequency of the vibrating cylindrical shell coinciding with operational frequency of rotating pump, amplitude of the vibration tends to infinite and cause devastating effected called resonance.

The significant exciting forces in the vertical pump occur at the operating speed Q, or Q times number of impeller blades Z, i.e. QZ [3]. The first natural frequency should be 10% above or below the pump operating speed [4]. To control the amplitudes vibrations, it is necessary to know the distribution of the natural frequencies, so it helps to design cylindrical shell cylindrical shell for optimum vibration control [5].

This paper illustrates modal analysis of vertical turbine pump base stool cylindrical shell. This paper also describes how to move natural frequency of the base stool cylindrical shell of VTP by stiffens existing cylindrical base stool shell.

Construction of Vertical Turbine Pump Base Stool Model

Base stool cylindrical shell 2-D drawing as shown in Figure 1 is built using modeling software. The bottom end of the base stool is rigidly fixed with foundation with mechanical fasteners. The other end of the base stool, motor is mounted which drives centrifugal pump at a speed of 1440 rpm which gives best efficiency for given head.

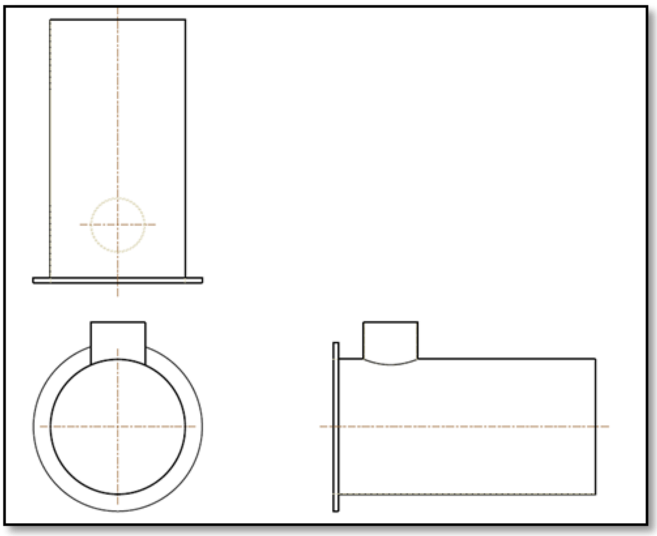

Figure 1: VTP Base Stool Cylindrical Shell Drawing

FINITE ELEMENT ANALYSIS

Finite element analysis is carried out to find out natural frequency of base stool cylindrical shell of vertical turbine pump. Following steps are performed to carry out finite element analysis.

Model

CAD model of vertical turbine pump is generated as shown in Figure 2

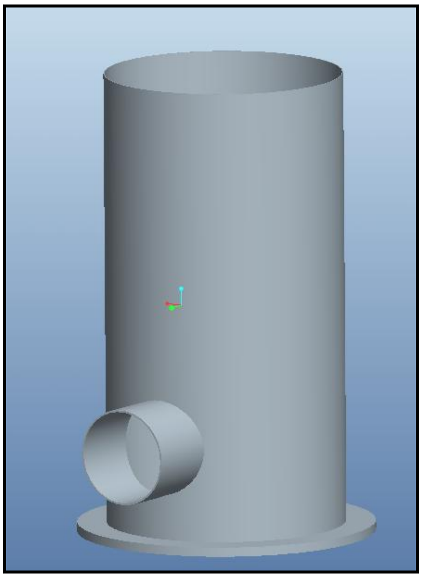

Figure 2: CAD Model of VTP Base Stool

Material Properties

Material properties for given base stool cylindrical shell are as shown table 1.

Table 1: Material Properties

Sr. No	Mechanical Properties	Value
1	Density	7850 kg/m^3
2	Young's Modulus	200 GPa
3	Poison's ratio	0.3

Meshing and Boundary Condition

Meshing model of vertical turbine pump base stool cylindrical shell is shown in Figure 3. Model is meshed with tetrahedral elements. Total number of nodes and elements are 68174 and 33729 respectively. Boundary condition of base stool is such that its bottom end is fixed i.e. all degree of freedom is zero. Top end of base stool cylindrical shell is free.

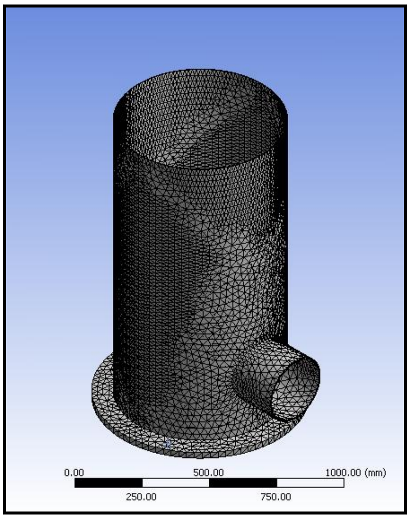

Figure 3: Mesh Model of VTP Base Stool

RESULTS AND DISCUSSIONS

Modal analysis reveals first six natural frequency of base stool cylindrical shell. Table 2 presents first six natural frequency of base stool. It was observed that fifth and sixth natural frequency is within the 10% margin of operational frequency 120 Hz. Figure 4 shows fifth and sixth mode shapes of vibration.

Table 2: First Six Natural Frequency

Mode	Natural Frequency (Hz)	Operational Frequency (Hz)	Margin in %
1	71.856	120	40.12
2	78.114	120	34.905
3	101.4	120	15.5
4	102.55	120	14.54
5	112.28	120	6.43
6	118.27	120	1.44

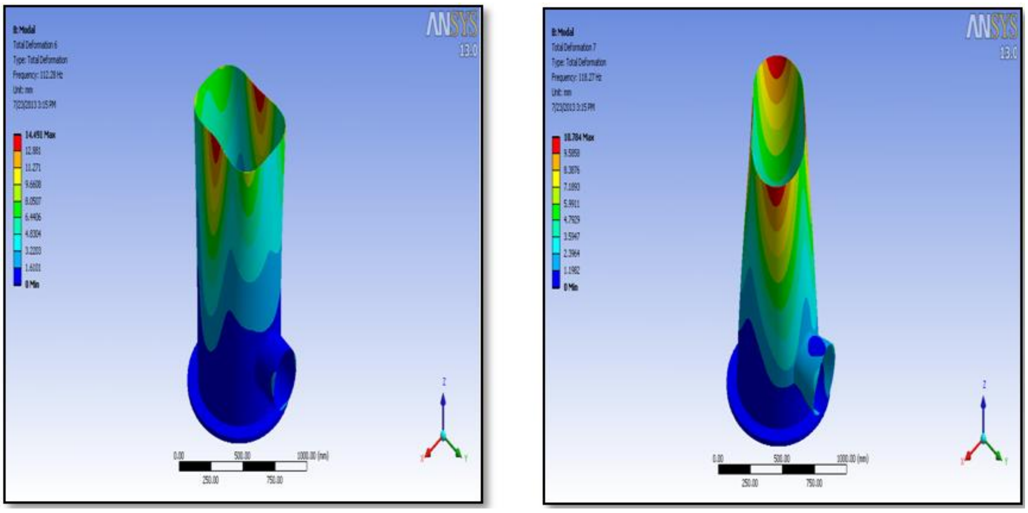

Figure 4: Fifth and Sixth Mode Shapes of Original Design

MODIFIED DESIGN AND FEA ANALYSIS

From the modal analysis of existing base stool cylindrical shell, it was observed that fifth and sixth natural frequencies of the base stool are within the 10% margin of operational frequency. So, to move natural frequency of base stool cylindrical shell away, stiffness has to be increased. Figure 5 shows modified design of VTP base stool cylindrical shell.

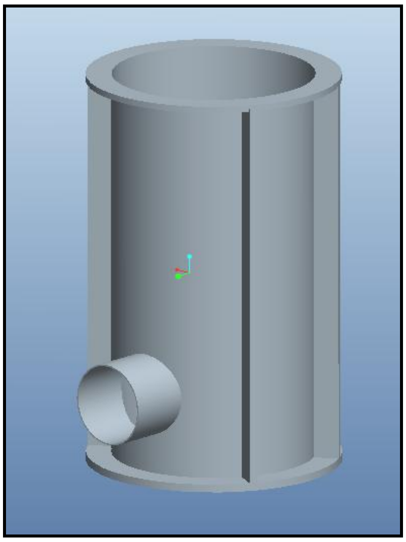

Figure 5: Modified Design of Base Stool Cylindrical Shell

FEA steps from 2.1 to 2.3 are carried out to perform modal analysis of modified design. First six natural frequency of modified model is shown in table 3. Also first two mode shapes of vibration are shown in Figure 6.

Table 3: First Six Natural Frequency for Modified Base Stool Cylindrical Shell

Mode	Natural Frequency (Hz)	Operational Frequency (Hz)	Margin in %
1	190.01	120	58.34
2	199.81	120	66.50
3	271.18	120	125.98
4	278.02	120	131.68
5	297.37	120	147.80
6	358.47	120	198.72

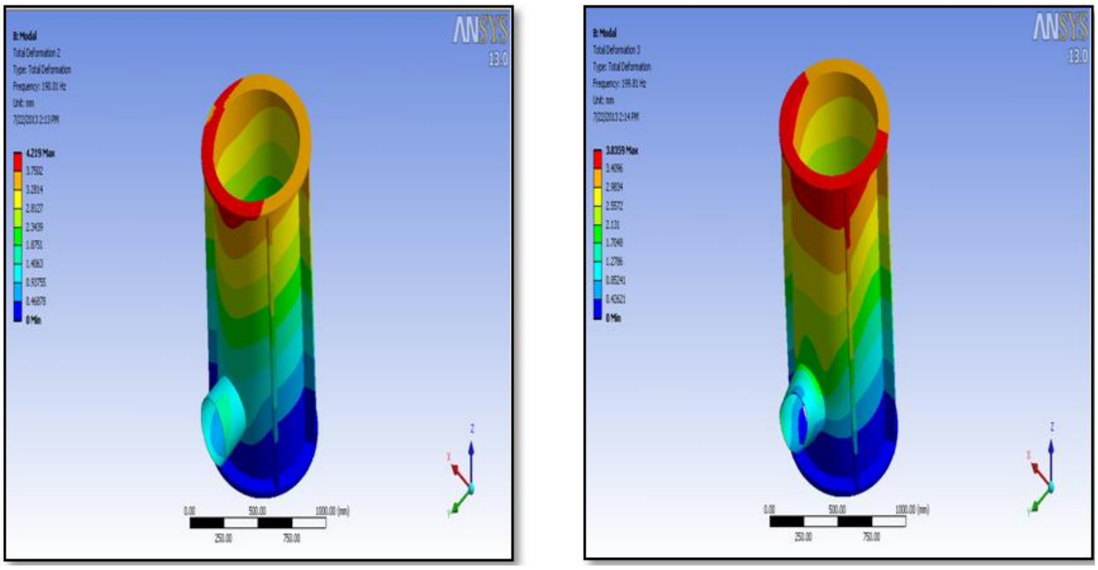

Figure 6: First and Second Mode Shapes of Modified Design

CONCLUSIONS

Finite element analysis is very useful tool to analyze dynamic behavior of base stool cylindrical shell. By modifying design of base stool cylindrical shell at earlier stage, resonance can be avoided which leads to catastrophic failure of cylindrical shell casing. To avoid resonance natural frequency of the cylindrical shell should not be in 10% margin of operational frequency of VTP. This can be done by increasing stiffness of base stool by providing longitudinal and circumferential ribs on existing cylindrical base stool.

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