Experimental and Numerical Noise and Vibration Analysis of Flour Mill Foundation

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Abstract - *Mechanical energy released by any source in a medium creates vibrations of molecules. The molecules start vibrating in the oscillatory mode and the energy travels through the medium in form of vibrations. Noise is usually defined as unwanted sound pollutant which produces undesirable physiological and psychological effects in an individual, by interfering with one's social activities like work, rest, recreation, sleep etc. Research in vibration control has been an on-going study for decades, ever since the invention of mechanical systems. The vibration causes the effect on the operator of machineries. Increase the Harshness level in working area. Continuous Noise & Harshness is hazardous for human being.*

With above motivation flour mill foundation was taken for vibration study to reduce the vibration level present in it and hence to reduce the overall vibration and noise present in system. The present work concentrates on comparison of numerical noise and vibration analysis of flour Mill and verification of same using the experimentation. In order to carryout numerical noise and vibration analysis Ansys Workbench is used.

Keywords: Flour Mill, Noise and Harshness, Vibration, Omnipotent, Ansys Workbench.

1. INTRODUCTION

Vibration is occasionally "desirable". For example the motion of a tuning fork, the reed in a woodwind instrument or harmonica, or the cone of a loudspeaker is desirable vibration, necessary for the correct functioning of the various devices [1].

The purpose of vibration isolation is to control unwanted vibration so that its adverse effects are kept within acceptable limits. Vibrations originating from machines or other sources are transmitted to a support structure such as a facility floor, causing a detrimental environment and unwanted levels of vibration. If the equipment requiring isolation is the source of unwanted vibration, the purpose of isolation is to reduce the vibration transmitted from the source to the support structure [2]. Conversely, if the equipment requiring isolation is a recipient of unwanted vibration, the purpose of isolation is to reduce the vibration transmitted from the support structure to the recipient.

A sound might be unwanted because it is: 1. Loud, 2. Unpleasant or annoying, 3. Intrusive or distracting.

Noise is also considered a mixture of many different sound frequencies at high decibel levels.

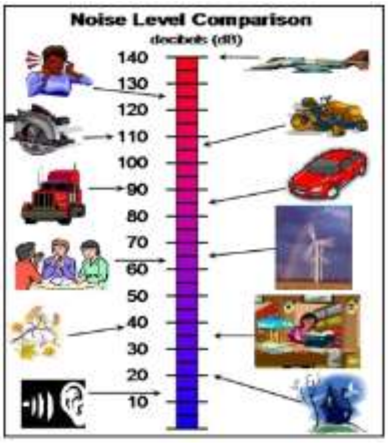

Fig-1 Noise Level Comparison

Noise pollution refers to sounds in the environment that are caused by humans and that threaten the health or welfare of human or animal inhabitants [3].

In India Flour Mills are often seen in each village, town and even district places, which are commonly used by people to grind the grains into flour. Most important concern about flour mill is noise and vibration from the flour mill. The objective of the study is to produce results which may help to rectify problems associated with mechanical systems design Continuous Noise & Harshness is hazardous for human being. In the case lightly damped structures can produce high levels of vibration from low level sources if frequency components in the disturbance are close to one of the system's natural frequencies [5]. This means that well designed and manufactured sub-systems, which produce low level disturbing forces, can still create problems when assembled on machineries. In order to avoid these problems, at the design stage it is necessary to model the system accurately and analyze its response to anticipated disturbances, in this research work a mathematical model of the system and formulate the equations of motion, analyze the vibration characteristics (natural frequencies and modes) the forced vibration response to prescribed disturbances. The present paper deals with comparison of

Modal analysis results using the Finite element method and Experimental modal analysis results. The CAD model created in 3D CAD modeling software was imported. For finite element analysis the ANSYS Workbench module was used.

2. EXPERIMENTATION

Experimentation is one of the scientific research methods, perhaps the most recognizable; in a spectrum of methods that also includes description, comparison, and modeling. While all of these methods share in common a scientific approach, experimentation is unique in that it involves the conscious manipulation of certain aspects of a real system and the observation of the effects of that manipulation. Experimentation gives real insight of the system. In order to find out actual results experimentation is necessary because in theoretical analysis behavior of system parameters considered is linear but in actual those system behaves nonlinear in actual practices, so in order to find out difference in theoretical and experimental analysis experimentation is necessary.

To carryout Experimental Modal Analysis following are the basic equipment required.

FFT Analyzer.

Modal Hammer

Accelerometer

Fig- 2 Four Channel FFT Analyzer

Fig-3 Accelerometer

Fig-4 Measurement at Foundation of Motor

Figure below shows the Experimental results obtained from modal analysis

Experimental Modal analysis of Motor Foundation:

Table No.1 Below indicates the natural frequencies of foundation

Sr. No.	Experimental Modal Analysis
1	140
2	170
3	180
4	450
5	510
6	780

Figure 5 shows experimental result for Modal Analysis of Motor Foundation.

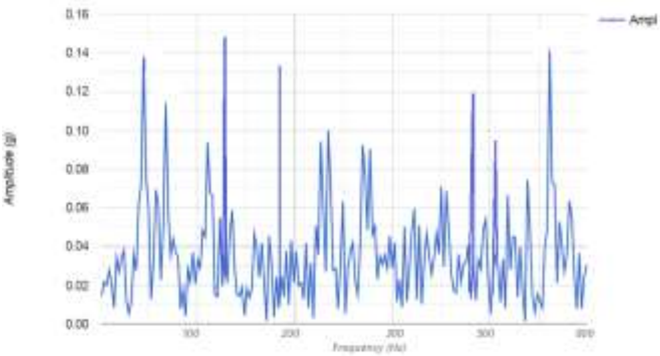

Fig-5 Modal Analysis experimental results

Noise Analysis of Flour Mill:

At Vetam Flour Mill, 16 observations recorded on 18 Oct, 2018 at day time only.17.37 % exceedence was recorded during day time. 59 to 67 dB (A) of sound level range recorded during day time. 16 observations fall in range of 55 to 65 dB (A) during day time. Standard deviation of 1 dB (A) depicts that sound level at Vetam Flour Mill always remain at 60 dB (A) which is above standard in Normal residential area as per CPCB, Government of India.

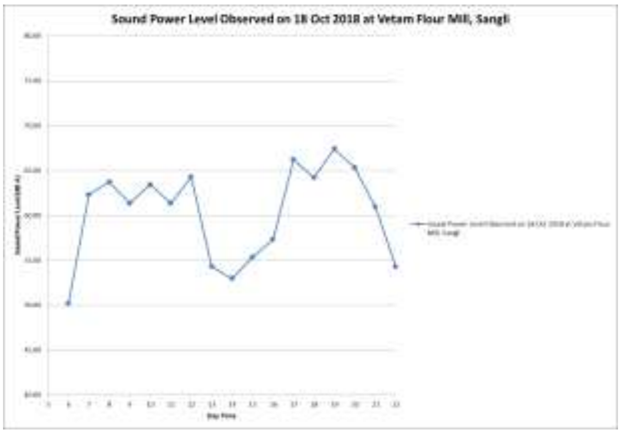

Fig-6 Noise Measurement Results

3. DESIGN MODIFICATION AND VERIFICATION:

Vibration and Noise Control Techniques:

- Modification is Structure of Foundation to increase the difference between Excitation frequency and Natural Frequencies' of Flour Mill Foundation.
- Modification is Structure of Foundation to increase the difference between Excitation frequency and Natural Frequencies' of Motor Foundation.
- Modification is Structure of Foundation to increase the difference between Excitation frequency and Natural Frequencies' of Flour Mill Assembly.
- Selection of Vibration Isolator.

Selection of Vibration Isolator for Motor Foundation:

Problem Statement: An electric motor driving the flour Mill is rigidly mounted on a base transmits vibration to other components of a system. The weight of the assembly and base is 100 Kg. Four isolators are to be located at the corners of the rectangular base. The lowest vibratory forcing frequency is 1440 rpm and is the result of rotational unbalance.

Objective: To reduce the amount of vibration transmitted to the supporting structure. A vibration isolation efficiency of 70 to 90 % is usually possible to obtain [4].

Here a value of 80 % is selected.

Solution: 1. First find transmissibility, T, which corresponds to the required vibration isolation of 80 percent, (I=.8)

$$T + I = 1$$

$$T = 1 - 0.8 = 0.2$$

Determine the forcing frequency fd in cycles per second (Hz). The lowest forcing frequency is used because this is the worst condition. If high isolation is attained at this frequency, isolation will be even better at higher frequencies.

$$\frac{1440}{60\ Sec/min} = fd = 24Hz$$

Determine the natural frequency fn that the isolated system needs to provide a transmissibility T = 0.2. The following equation assumes zero damping.

$$T = \frac{1}{\left(\frac{fd^2}{fn^2}\right) - 1} \ldots\ldots solve\ for\ fn$$

$$fn = 9.79Hz$$

Calculate the load at each mounting point. If the center of gravity of the supported mass is centrally located in the horizontal plane, simply divide the total weight by the number of mounting points.

$$\frac{100Kg}{4} = 25kg/Mounting$$

Determine the required static deflection and spring rate. Static deflection (ds) for this natural frequency is calculated with the formula

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$ds = \frac{9.8}{fn^2}$$

$ds = 0.1022$ inches

The required spring rate (k) can be calculated with the formula:

$$K = \frac{Load\ in\ lbs}{Static\ Deflection\ in\ inch}$$

$$K = \frac{308.67}{0.1022} = 3020.25lbs/inch$$

3020.25 lbs./in. is the required spring rate for an isolator at mounting point. This calculation can be completed using the total weight so the spring rate (k) calculated will be a total spring rate rather than a per mount spring rate. Dividing by the number of mounts will equal a per mount spring rate.

Select a mount that has a maximum load rating equal to or greater than the supported point load and a spring rate equal to or smaller than the calculated value.

For our example the load/mount is 77 lbs., and the spring rate is 3020 lbs./in. (528.8830 N/mm)

We can select 4 pieces of part number 200 P- 77 which are rated at 77 lbs. with a spring rate of 3020 lbs./ in. (528.8830 N/mm).

So same can be checked using ANSYS workbench.

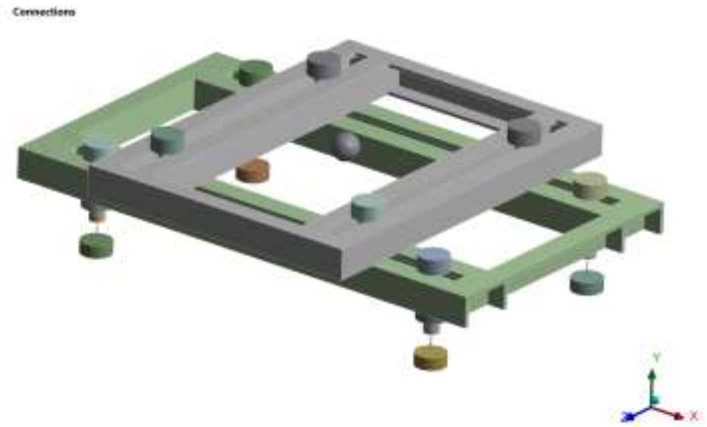

Fig-7 Isolators at four fixation locations

In order to isolate the vibration from motor foundation, it is decided to add the isolator damper, After Addition of damper Modal frequencies shifted away from the motor working range.

Table No-2 Comparison of Old and Modified Design

Mode Shape No.	Motor Foundation Modification		
	Numerical Modal Frequencies (Hz) Old Design	Numerical Modal Frequencies (Hz) Modified Design	% Variation
1	137.5	175.08	21.4
2	176.01	381.15	53.8
3	179.5	691.4	74.0
4	455.47	739.71	38.4
5	508.56	746.61	31.8
6	779.24	782.05	0.35

From above table it can be clearly seen that using the isolators Vibration and Noise problem in Motor foundation can eliminated. Figures below shows the mode shapes of Motor foundation structure with isolator. Isolators are selected to already modified structure of motor foundation as to improve additionally.

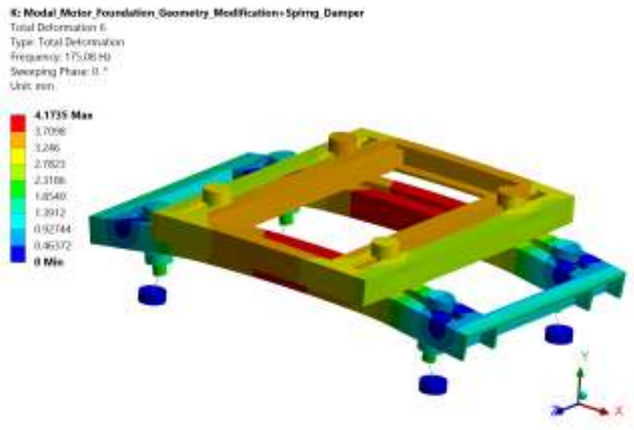

Fig-8 Mode Shape No.1

Fig-9 Comparison of Sound power level in Flour Mill Area

CONCLUSION

From Table 2 it is observed that percentage shift in frequencies of motor foundation is observed. Maximum percentage shift of 75% is observed in motor foundation without isolator and motor foundation with isolator.

Also from fig 9 shows the comparison between sound power level measurements performed on 18 Oct 2018 and 12 Jan 2019 respectively. From graph it is clearly seen that around 20 to 25% reduction in noise is achieved in flour mill area. Now average sound power level at Vetam flour mill is around the 48dB (A) which is below the standard in Normal residential area as per CPCB, Government of India.

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