Design of Vibration Isolator for Machine-tool

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ABSTRACT

Our project work mainly deals with design of vibration isolator for milling machine, which is being vibrated due to transmission of vibration from its neighbouring machine tool through ground. The vibration signature of the vibrating machine and its attenuation during transmission through ground is considered and the resultant exciting force amplitude is determined. The vibration isolator is designed to isolate the milling machine from that exciting for considering maximum allowable amplitude for cutter of milling machine. The result is also analysed and verified using Ansys.

Keywords: *ANSYS, Amplitude, Milling machine, Pro-E, Vibration isolator.*

I. INTRODUCTION

Vibration is a term that describes oscillation in a mechanical system. It is defined by the frequency (or frequencies) and amplitude. Either the motion of a physical object or structure or, alternatively, an oscillating force applied to a mechanical system is vibration in a generic sense. Conceptually, the time-history of vibration may be considered to be sinusoidal or simple harmonic in form. The frequency is defined in terms of cycles per unit time, and the magnitude in terms of amplitude (the maximum value of a sinusoidal quantity). The vibration encountered in practice often does not have this regular pattern. It may be a combination of several sinusoidal quantities, each having a different frequency and amplitude. If each frequency component is an integral multiple of the lowest frequency, the vibration repeats itself after a determined interval of time and is called periodic. If there is no integral relation among the frequency components, there is no periodicity and the vibration is defined as complex. Vibration isolation concerns means to bring about a reduction in a vibratory effect. A vibration isolator in its most elementary form may be considered as a resilient member connecting the equipment and foundation. The function of an isolator is to reduce the magnitude of motion transmitted from a vibrating foundation to the equipment or to reduce the magnitude of force transmitted from the equipment to its foundation. Our project work mainly deals with design of vibration isolator for milling machine, in which is being vibrated due to transmission of vibration from its neighboring machine tool through ground. The vibration signature of the vibrating machine and its attenuation during transmission through ground is considered and the resultant exciting force amplitude is determined. The vibration isolator is designed to isolate the milling machine from that exciting for considering maximum allowable amplitude for cutter of milling machine. And the result is also analysed and verified using Ansys.

II. CONCEPT OF VIBRATION ISOLATION

The concept of vibration isolation is illustrated by consideration of the single degree-of-freedom system illustrated in Fig. 1. This system consists of a rigid body representing equipment connected to a foundation by an isolator having resilience and energy dissipating means; it is unidirectional in that the body is constrained to move only in vertical translation. The performance of the isolator may be evaluated by the following characteristics of the response of the equipment-isolator system of Fig. 1 to steady-state sinusoidal vibration.

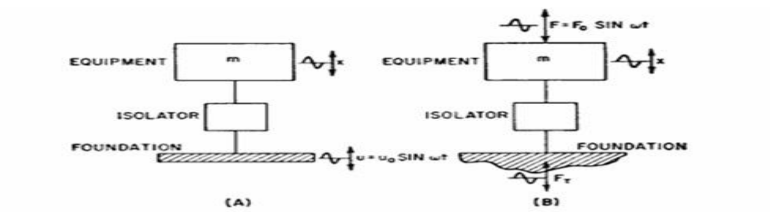

Fig.1 vibration isolation

- **Absolute transmissibility**: Transmissibility is a measure of the reduction of transmitted force or motion afforded by an isolator. If the source of vibration is an oscillating motion of the foundation (motion excitation), transmissibility is the ratio of the vibration amplitude of the equipment to the vibration amplitude of the foundation. If the source of vibration is an oscillating force originating within the equipment (force excitation), transmissibility is the ratio of the force amplitude transmitted to the foundation to the amplitude of the exciting force.

- **Relative transmissibility**: Relative transmissibility is the ratio of the relative deflection amplitude of the isolator to the displacement amplitude imposed at the foundation. A vibration isolator effects a reduction in vibration by permitting deflection of the isolator. The relative deflection is a measure of the clearance required in the isolator. This characteristic is significant only in an isolator used to reduce the vibration transmitted from a vibrating foundation.

- **Motion response:** Motion response is the ratio of the displacement amplitude of the equipment to the quotient obtained by dividing the excitation force amplitude by the static stiffness of the isolator. If the equipment is acted on by an exciting force, the resultant motion of the equipment determines the space requirements for the isolator, i.e., the isolator must have a clearance at least as great as the equipment motion.

III. VIBRATION IN MACHINE TOOLS AND THEIR ISOLATION

Machining and measuring operations are invariably accompanied by relative vibration between work piece and tool. These vibrations are due to one or more of the following causes: (1) in homogeneities in the work piece material; (2) variation of chip cross section; (3) disturbances in the work piece or tool drives; (4) dynamic loads generated by acceleration/deceleration of massive moving components; (5) vibration transmitted from the environment; (6) self-excited vibration generated by the cutting process or by friction (machine-tool chatter). The tolerable level of relative vibration between tool and work piece, i.e., the maximum amplitude and to some extent the frequency, is determined by the required surface finish and machining accuracy as well as by detrimental effects of the vibration on tool life and by the noise which is frequently generated.

IV. CASE STUDY OF MACHINE-TOOL VIBRATIONS

A heavy machine tool mounted on the first floor of a building has been modeled as a three degree of freedom system.

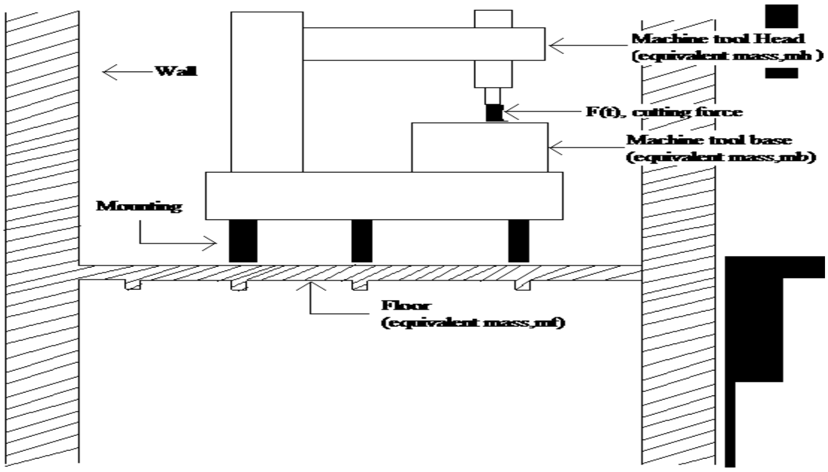

Fig 2 Diagram of drilling machine

V. ISOLATION OF MILLING MACHINE

Ground vibrations from an air compressor is transmitted to a nearby milling machine and is found to be detrimental to achieving specified accuracies during precision milling operations.

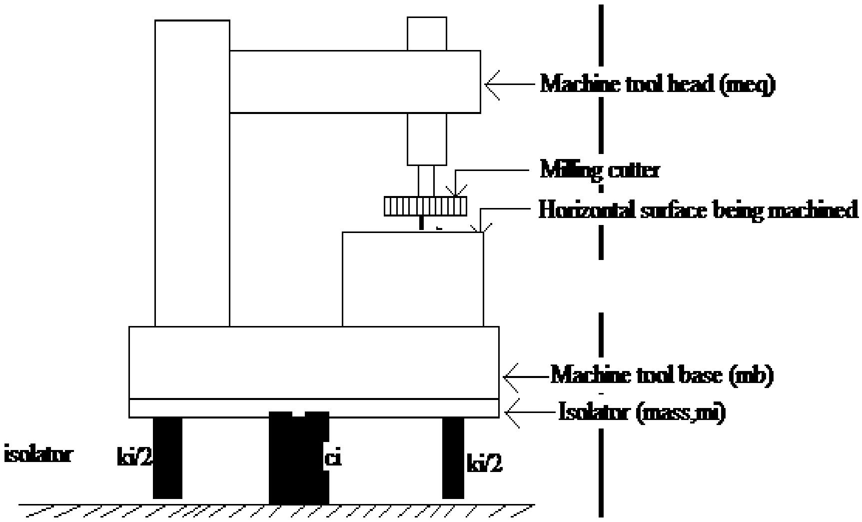

Fig 3 Diagram of milling machine

VI. VERIFICATION USING ANSYS

The result is verified using Ansys. The following are the procedural steps to be followed to perform harmonic analysis.

- **Starting with Ansys**
  1. File → clear & start new → Do not read file → OK → Yes.
  2. File → change job name → vibration analysis → OK.
  3. File → change title → harmonic analysis → OK.
  4. Main menu → Preferences → structural → h-method → OK

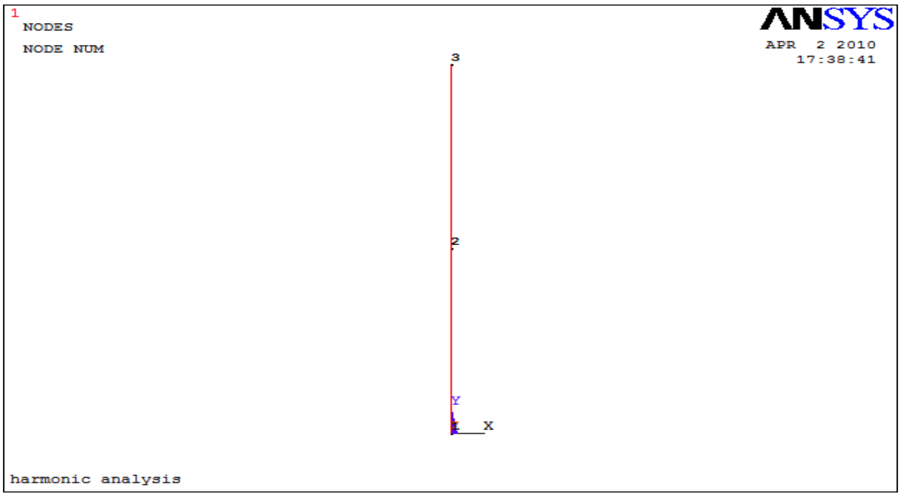

Fig.4 Nodal diagram

- **Specify the analysis type, MDOF, and load step specifications**

[1] Main menu → solution → Analysis type → New analysis.
[2] Click once on “Harmonic” and click on OK.
[3] Main menu → solution → Analysis type → Analysis options
[4] Click on “Full” to select the solution method.
[5] Click on “amplitude-phase” to select the DOF printout format and click on OK.
[6] Main menu → solution → Load step opts → Time/Frequenc → Freq and substeps.
[7] Enter 0 & 20 for the harmonic frequency range.
[8] Enter 30 for the number of substeps.
[9] Click once on “stepped” to specify stepped boundary conditions.
[10] Click on OK.

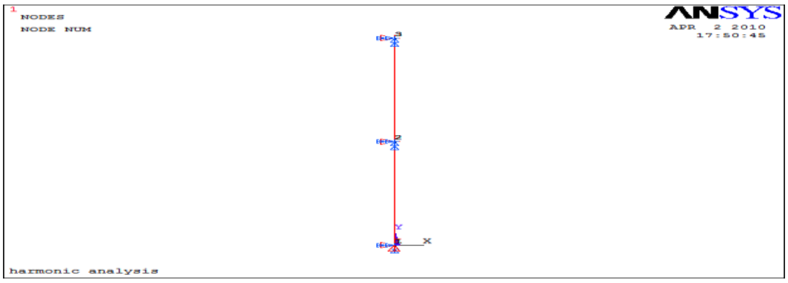

Fig .5 Application of load on nodes

- **Solving the Model**

[1] Main menu → solution → solve → current LS
[2] Review the information in the status window and click on close.
[3] Click on OK on the solve current Load step dialog box to begin the solution.
[4] When the solution is finished, a dialog box starting “Solution is done!” appears.
[5] Click on close.

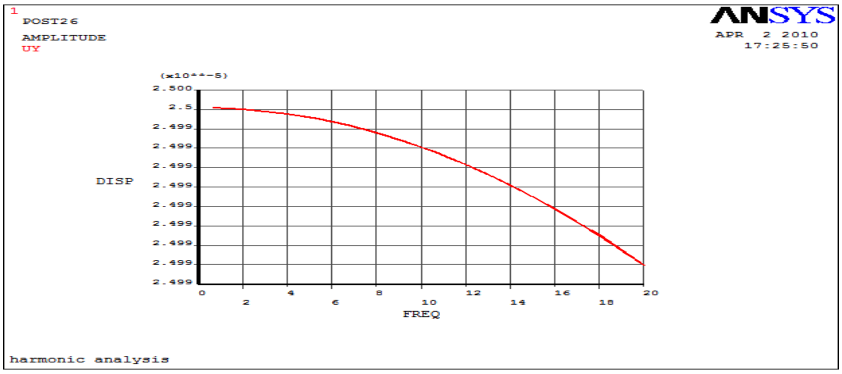

Fig 6 Frequency Vs Amplitude

VII. RESULTS AND DISCUSSION

We have designed a vibration isolator for milling machine. Theoretically we designed the isolator whose mass is obtained as 4060Kg with the help of given displacement of cutter as 2.5×10^{-6}m. We solved the same using harmonic analysis in Ansys an analysis package. In Ansys we gave the mass and found the displacement of cutter axis. We got the graph as shown in the figure below.

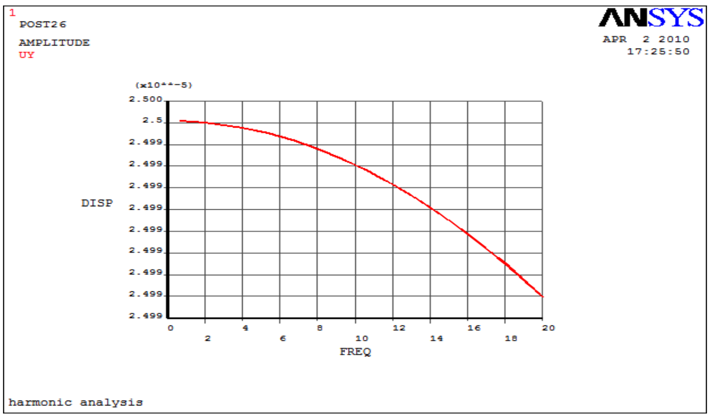

Fig 7 Frequency Vs Amplitude

From the graph it is clear that the maximum amplitude is 2.5×10^{-6}m.
From above it is clear that the results obtained in both the cases i.e. theoretical value as well as the value obtained by Ansys are same.

VIII. CONCLUSION

The vibration isolator for a milling machine being excited by neighboring machine was designed successfully theoretically, and is verified using ANSYS software. A vibration isolator for milling machine is designed. Theoretically designed isolator has a mass of 4060Kg with the help of given displacement of cutter as 2.5×10^{-6}m. The same was verified using harmonic analysis in Ansys an analysis package. In Ansys the displacement of cutter axis is found and the graph is plotted, from which it is clear that the maximum amplitude is 2.5×10^{-6}m.Thus, the results obtained in both the cases i.e. theoretical value as well as the value obtained by Ansys are same.

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