Analysis of Vibration of Radial Drilling Machine Structure Using Finite Element Method.

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ABSTRACT

Machine tools are today held to high standards in the manufacturing industry, including both terms of productivity and product quality. Vibration is a key factor in judging product quality. If the patterns of vibration found in the tools of machine during the process of cutting is understood, the structure of machine tool may be constructed such that the frequency response of the structure of machine tool is separated from the forced frequency. As a result, the goal of this research is to determine the inherent frequency and mode forms of the radial drilling machine construction. The inherent frequencies and mode shapes of the radial drilling machine construction were determined using finite element analysis.

***Key Words*: Machine tools, product quality, radial drilling machine, Inherent frequency**

1.INTRODUCTION:

Vibration issues have become more important as the requirement for precision and output has grown. Vibrations, both sustained and forced, have been shown to reduce reliability and production. Vibrations are produced by all machine tools. A rise in levels of vibration is always accompanied by a decline in condition of the machine. The signals of the vibration have shown to be among the most dependable criteria for checking machine status in monitoring health of machine. The goal of machine tool vibration analysis is to keep the helpful oscillations and eliminate the undesired ones. The goal of this research is to show that if the frequency response of a tool of machine construction is known ahead of time, forced frequencies acquired during cutting may be separated from the natural frequency in order to avoid resonance.

For vibration monitoring of plates, Bellman et al. devised the Differential quadrature (DQ) technique. Leiw et al. applied this approach for analysis of vibration of plated shaped rectangular subsequently. For the examination of plate mechanical behavior, Wei employed the DSC (discrete singular convolution) approach. Utilizing experimental and analytical data, R.S. Bais et al. improved FE models of a drilling machine. I-DEAS software was used to do quantitative FE modeling. For vibration study of an elevated drilling machine, Nanda et al. discovered natural frequencies and mode shapes. M. Rantatalo et al. provided a tool for evaluating vibrations - lateral, in a milling machine spindle that used FEM (finite element modeling). Weiwei et al. investigated the dynamic characteristics of the XK717 CNC milling machine using the finite element technique. For free vibration, static, and bowing calculations of Reissner–Mindlin plates utilizing 3-node triangular elements, researchers combined an edge-based smoother finite element technique (ES- FEM) with the DSG (discrete shear gap) approach. The technique of calculating the frequency response and regular vibration modes of flexible shells of revolutions with an arbitrary meridian, partially filled with a fluid, was described by Ventsel et al.

Problem Formulation of Radial Drilling Machine Structure:

The fundamental matrix equation for a system's dynamics is:

$[M]\{\ddot{x}\} + [C]\{\dot{x}\} + [K]\{x\} = [q]$ (1)

Assuming un-damped free vibration, harmonic motion, equation (1) becomes to:

$[K]- [M] \{X\} = 0$ (2)

where [K]=stiffness matrix, [M]=mass matrix

For obtaining the natural frequencies & related modal shapes, the inverse iteration approach may be used to solve Equation (2).

The stiffness matrix for an element in the frame is provided by as the length of the element is parallel to the x-axis: $[k]e = A\int 0\ell\ [B]T\ [D]\ [B]\ dx$ (3)

Where, [K]e = Elemental stiffness matrix, [B] = [L] [N], [L] = [-d2/dx2], D= E*I

A frame element's mass matrix is provided by when the element's length is parallel to the x-axis.

$[m]^e = A\int_0^{\ell} \rho\, [N]^T [N]\, dx$ (4)

When the element's length is perpendicular to the y-axis, the rows and columns of the stiffness matrices and elemental mass and relating to the directions of x and y are swapped.

Figure 1 depicts the simplified construction of the radial drilling machine ( ), which is used in the FE analysis. The structure's dimensions are all in millimeters.

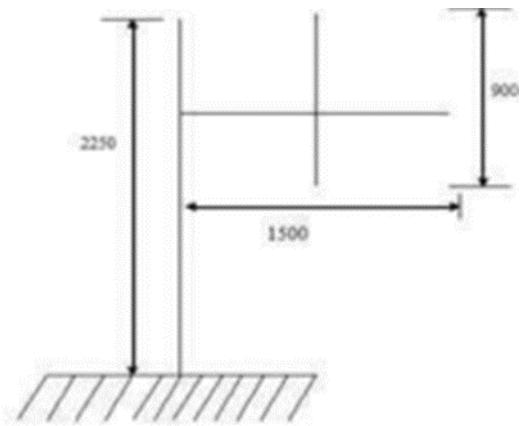

Figure1 structure for FE analysis

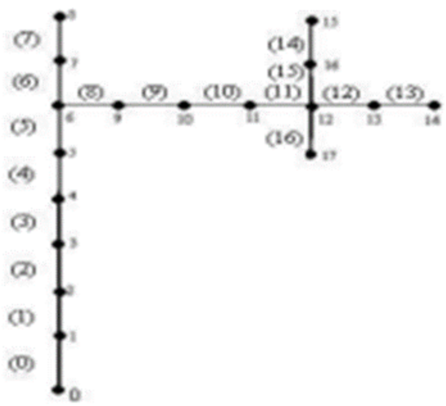

Figure 2 The ' '- Structure with node numbers

A software written in C is used to find both eigen vectors and values. The basic mode forms generated from the C program and the IDEAS Program are very similar, as can be seen from the comparisons. The displacements provided by the Source file and the IDEAS program differ somewhat. That's perfectly okay. As a result, the C software for vibration analysis of the 'shaped structure' has been certified.

2. ANALYSIS PROCEDURE:

The following are the steps in an analysis of stature's finite element vibration:

1. There are seventeen17 two-nodded frame elements and 18 nodes in the structure. Each node has 2 degrees of freedom in terms of displacement and rotation. As a result, each piece has 6 degrees of freedom, giving the overall structure 54 degrees of freedom. Figure 2 depicts the discretized structure.

2. For the structure, a component connectivity table is created, which displays which component is linked to which node pairs.

3. Equations three and four are used to calculate elemental mass matrices and stiffness matrices. 4. System mass and stiffness matrices are produced using typical assembly techniques in FEM. 5. The stiffness and mass matrices of the system are altered in accordance with the parameter, which in this case is that the displacements at the fixed node are 0.

6. The generated eigen value may be solved using the inverse iteration approach.

VIBRATION ANALYSIS OF RADIAL DRILLING MACHINE STRUCTURE:

The analysis of a vibration drill press machine construction makes the following assumptions:

• The construction of the drilling machine is 2-D.

• The construction is assumed to be one piece and the joints are presumed to be stiff.

• Damping isn't taken into account.

• Switches, a wider machine base, and a motor operating the drill are not taken into account because they do not add to the stiffness of the drill machine construction.

• At the grounded mode, displacements are believed to be zero. Radial Drilling Machine Structure FE Modeling: Figure 3 shown a radial drilling machine. It is modelled as a ' ' Structure as shown in figure 2**.** 8,9,10,11,12,13 of the framed structure shown in (figure 2). The

drilling machine's shaft is tapered, with higher width nearer the pillars and decreased breadth at the end. As illustrated in figures 4 and 5, the complete length of the arm is split into six frame pieces of equal length but varying breadth.

Figure 3 Radial Drilling Machine

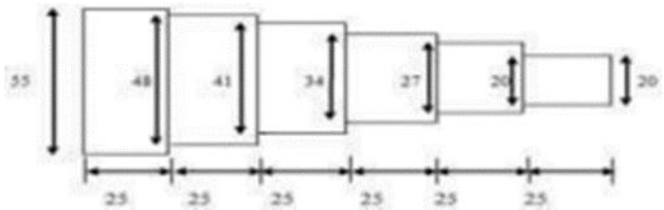

Figure 5 Frame elements representing the column of drilling

The FE model of the radial drilling machine structure is obtained as discussed below:

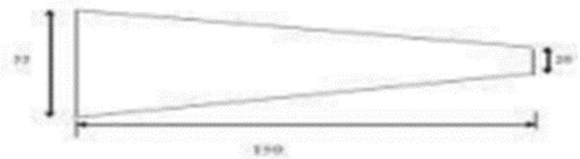

Figure 4 Column of drilling machine structure

- The framed structure shown in (figure 2) has 17 components and 18 nodes.

- The column of the drilling machine construction is represented by element numbers

The form of the pillar of the drilling machine construction will be approximated by these six parts:

- The drilling head construction of a radial drilling machine is represented by element numbers 14, 15, 16 of the framed structure (fig. 2). Elements of the frame type with a rectangular cross section are used.

- The pillar of the drilling machine construction is represented by element numbers 1,2,3,4,5,6,7 of the framed structure. The cross-section of the pillar of a drilling machine is round.

- The framed structure's element no. 0 represents the drilling machine's base. The cross-section of the element is round.

3. RESULTS AND DISCUSSION:

The vibration study of the machine of Radial Drilling is performed using the algorithm that has already been verified for analysis of vibration of the" shaped structure. Figure 6 shows that nodes 1,2,3,4,5,6,7, and 8 (refer to fig 2 & all correspond to pillar of radial drilling machine structure) in the fundamental mode shape (corresponding to fundamental natural frequency 35.68 Hz) show displacements along positive x-axis from the corresponding positions on the un-deformed machine structure. Nodes 9, 10, 11, 12, 13, and 14 (corresponding to a drilling machine column) reveal displacements beneath the un-deformed structure. Drilling head of radial drilling machine structure Nodes 15,16,12, and 17 exhibit displacements to the right of the corresponding places on the un-deformed machine structure.

Table1First three natural frequencies obtained from C program

Mode No.	Frequency (Hz)
1	35.68
2	52.24
3	318.7

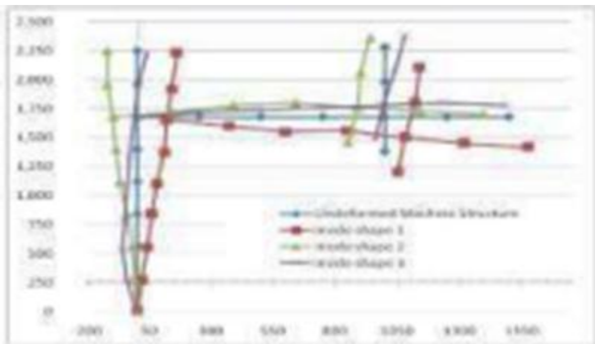

Figure 6 first three mode shapes of the structure

In the 2nd mode shape (around 2nd natural frequency 52.24 Hz), node no. 9, 10,11,12,13 shows displacements above the un deformed machine structure, whereas node no. 14(all correspond to column of radial drilling machine) is overlapping with the un deformed machine structure. Nodes corresponding to pillar of drilling machine (i.e., node no. 2,3,4,5,6,7,8) shows displacement along negative x-axis from the undeformed structure and node no.1 is overlapping with the un-deformed structure. Drilling head (i.e., element no.14,15,16 fig. 2) vibrates left side of the un-deformed structure.

In the 3rd mode shape (corresponding to third natural frequency 318.7 Hz), column of radial drilling machine (i.e., node no. 9,10,11,12,13,14) vibrates above the undeformed drilling structure. Nodes corresponding to pillar of drilling machine (i.e., node no. 1,2,3,4,5) shows displacement along negative x-axis from the un-deformed structure, whereas node no.6,7 are overlapping with un-deformed structure and node no. 8 shows displacement in positive x-axis from the un-deformed machine structure. Element no. 14, 15 vibrates right side, where as element no.16 (all correspond to drilling head of machine structure) vibrates left side of the un-deformed machine structure. So, from fig.6, by studying the first three mode shape, the vibration pattern of drilling machine structure can be visualized.

4. CONCLUSIONS

The following conclusions can be formed based on the findings and debates offered in this study:

a)At various positions on the un-deformed structure, the pillar of the structure of radial drilling machine vibrates most of the time along the positive x-axis with maximum displacement, the column of the radial drilling machine structure oscillates below, and the drilling head of the radial drilling machine structure vibrates right side of the corresponding positions on the un-deformed structure.

b)At naturally higher frequencies, i.e. from the third natural frequency onwards, the pillar of the radial drilling machine structure oscillates very near to un-deformed positions along the positively or negatively x-axis, the column of the radial drilling machine structure oscillates below the corresponding positions on the un-deformed structure, and the drill head of the radial drilling machine structure oscillates right hand side with some elements and left side with the remainder of the components from the radial drilling.

c)The pillar of a radial drilling machine structure vibrates along negative x-axis, the column of a radial drilling machine structure vibrates below and above, and the drilling head of a radial drilling machine structure vibrates left side of the corresponding positions on the undeformed structure in the 2nd mode shape (around 2nd natural frequency) of various cases.

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