

## Research Article

### Analysis of the Food Processing Precision Grinder Bed Modal Based on ANSYS Workbench

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**Abstract:** This study describes the finite element analysis in the applications of food processing machine design, according to the actual application, using ANSYS Workbench software, food processing precision Grinding of L-shaped bed by the finite element model, based on the use of the property to define the parameters and boundary conditions, modal analysis and by the various vibration modes.

**Keywords:** ANSYS, finite element model, food processing machine design

#### INTRODUCTION

With the continuous development of science and technology, the expansion of the grinding wheel speed range, spindle power increasing, the dynamic characteristics of food processing machine bed demand is higher and higher, exist in the traditional design method based on experience design cycle is long, large lathe bed weight, low reliability, need to be solved. Dynamic and static characteristics of food processing machine tools abroad research development soon, has a large number of finite element method is used to analyze and optimize the structure of food processing machine tool. Elbestawi *et al.* (2002) analyzes the processing method of combining high-speed milling and grinding and establish the CAD model by the Finite Element Analysis (FEA) to solve the components of each order modal vibration mode and vibration natural frequency. Lin *et al.* (2003) using the finite element model combined with the dynamic test method, in consideration of the case for pre-loaded speed food processing machine tool spindle coupling structure and thermal analysis. In recent years, the domestic application of the finite element method for analysis of the food processing machine structure in large numbers, (Xiaolong *et al.*, 2014) by using BP neural network is put forward to optimize the structure of food processing precision grinder bed method, on the grinder bed size optimization. Ni *et al.* (2005) Using finite element method, the static and dynamic analysis of food processing machine tool bed and using progressive structural optimization algorithm based on the bed structure of the fundamental constraints and rigidity constrained topology optimization.

#### MATERIALS AND METHODS

**Modal analysis of multi-DOF system:** Set the system for the degrees of freedom is N linear time-invariant systems, the motion differential equation is:

$$M\ddot{X} + C\dot{X} + KX = F \quad (1)$$

In the formula: M is the mass matrix system, C is the damping matrix system, K is the stiffness matrix of the system, they are (N×N) Order Matrix. X is the displacement of the point's system response vector; F is the point's system excitation force vector (Fu and Hua, 2000). The basic problem of modal analysis is to become the coupling equations, differential equations group of independent non-coupled. The Eq. (1) Pull conversion, you can get:

$$(s^2M + sC + K)X(s) = F(s) \quad (2)$$

In the formula:

$$s = \sigma + j\tau, s^* = \sigma - j\tau \quad (3)$$

To pull transformation factor;  $X(s)$ ,  $F(s)$  respectively for the displacement response and the exciting force of pull transformation (initial conditions to zero):

$$X(s) = \int_{-\infty}^{\infty} x(t)e^{-st} dt, F(s) = \int_{-\infty}^{\infty} f(t)e^{-st} dt \quad (4)$$

Let  $Z(s) = s^2 M + s^2 M + sC + K$ , Z (s) as the N×N matrix, which is the formula (2) becomes:

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Fig. 1: Three-dimensional map of food processing precision Grinding bed

$$Z(s)X(s) = F(s) \tag{5}$$

Let  $H(s)$  as  $Z(s)$  of the inverse matrix, then:

$$H(s) = Z^{-1}(s) = (s^2M + sC + K)^{-1} \tag{6}$$

For linear time-invariant systems, which left half plane pole in the complex plane, so can therefore be replaced by  $j\omega$ , get:

$$Z(\omega) = K - \omega^2M + j\omega C \tag{7}$$

$$H(\omega) = Z^{-1}(\omega) = (K - \omega^2M + j\omega C)^{-1} \tag{8}$$

In this case, the equation of motion for the system is:

$$(K - \omega^2M + j\omega C)X(\omega) = F(\omega) \tag{9}$$

By the vibration theory knowledge, linear time-invariant systems, the system response can be expressed

at any point as a linear combination of each modal response, the response to  $l$  points can be expressed as:

$$x_l(\omega) = \sum_{r=1}^N \varphi_{lr} q_r(\omega) \tag{10}$$

In the formula,  $\varphi_{lr}$  is the first measuring point's  $l$ , the modal factor of  $R$ -modal.  $\varphi_r$  as the first order modal vector  $r$ , it reflects the shape of the order vibration modes.

## RESULTS AND DISCUSSION

**The establish and modal analysis of food processing precision grinding bed finite element model:** Food processing precision Grinding bed is made of gray cast iron as a whole, the overall L-shaped layout, long edge 1715 mm, short edge 1626 mm, width 846 mm, height 400 mm, bed surface collector tank for coolant return, there are eight pads Rail mounting holes, two lifting holes, bed inside the body as well-shaped ribs, its three-dimensional structure as shown in Fig. 1.

The three-dimensional model of the bed to import ANSYS Workbench, the finite element model is established. Since the bed structure is more complex, without changing the model based on the characteristics, simplifying the holes, thread and other effects of fine mesh structure. In bed structure smallest fillet 1/2 40 mm as the standard, to determine the minimum mesh of 20 mm, 3D model mesh. Each finite element model parameters are shown in Table 1, the finite element model is shown in Fig. 2.

Table 1: Finite element model parameter input table

Material properties				
Unit type	Elastic modulus	Poisson's ratio	Density	Fixed fulcrum
Quadratic Tetrahedron	6.62e10 (N/m <sup>2</sup> )	0.27	7200 (kg/m <sup>3</sup> )	8

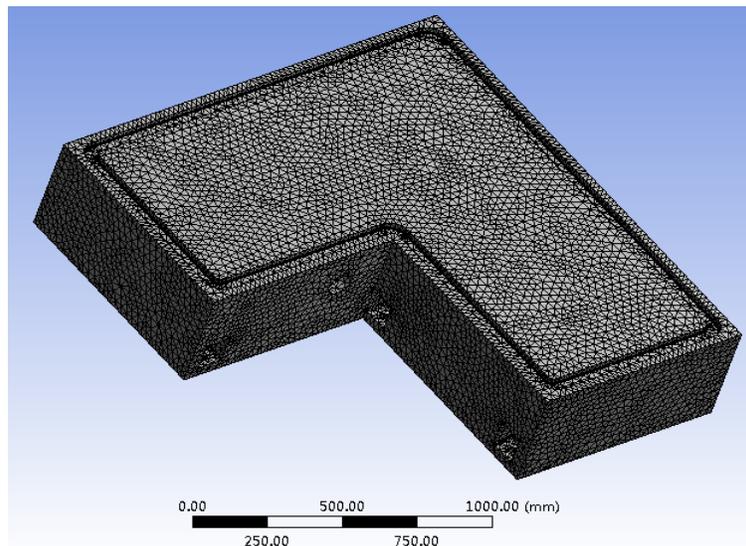
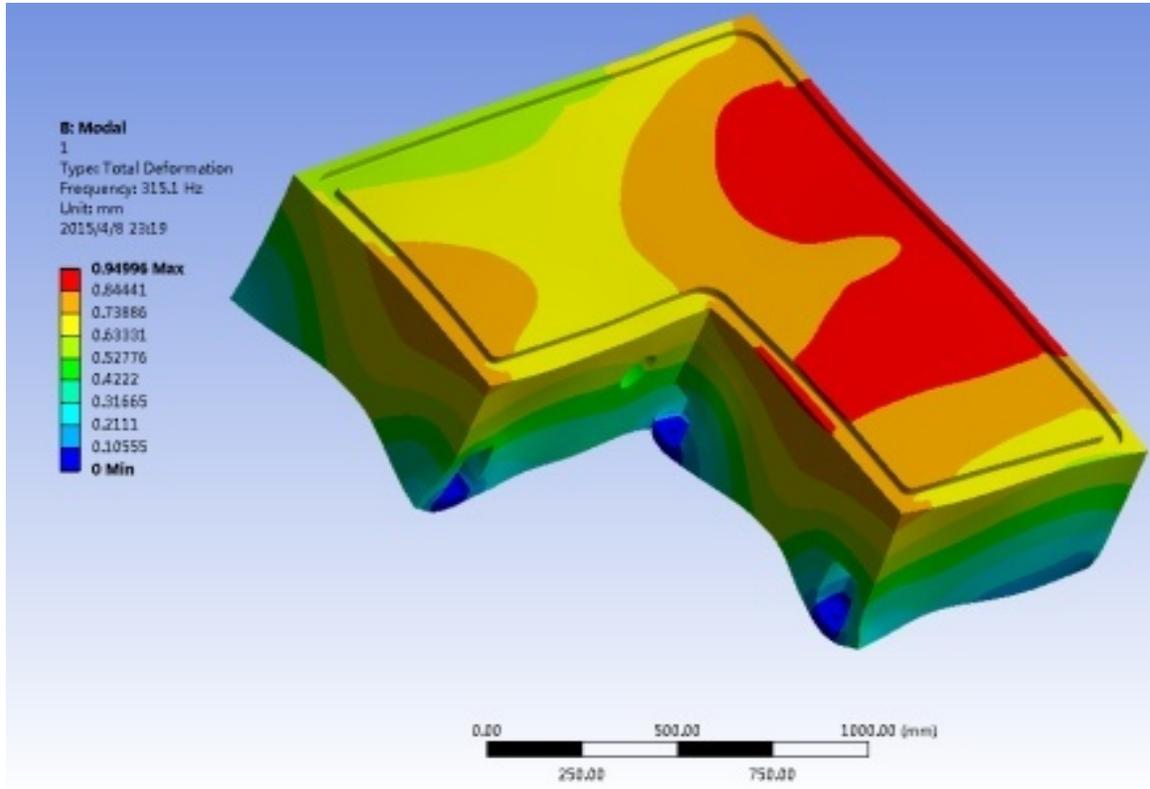
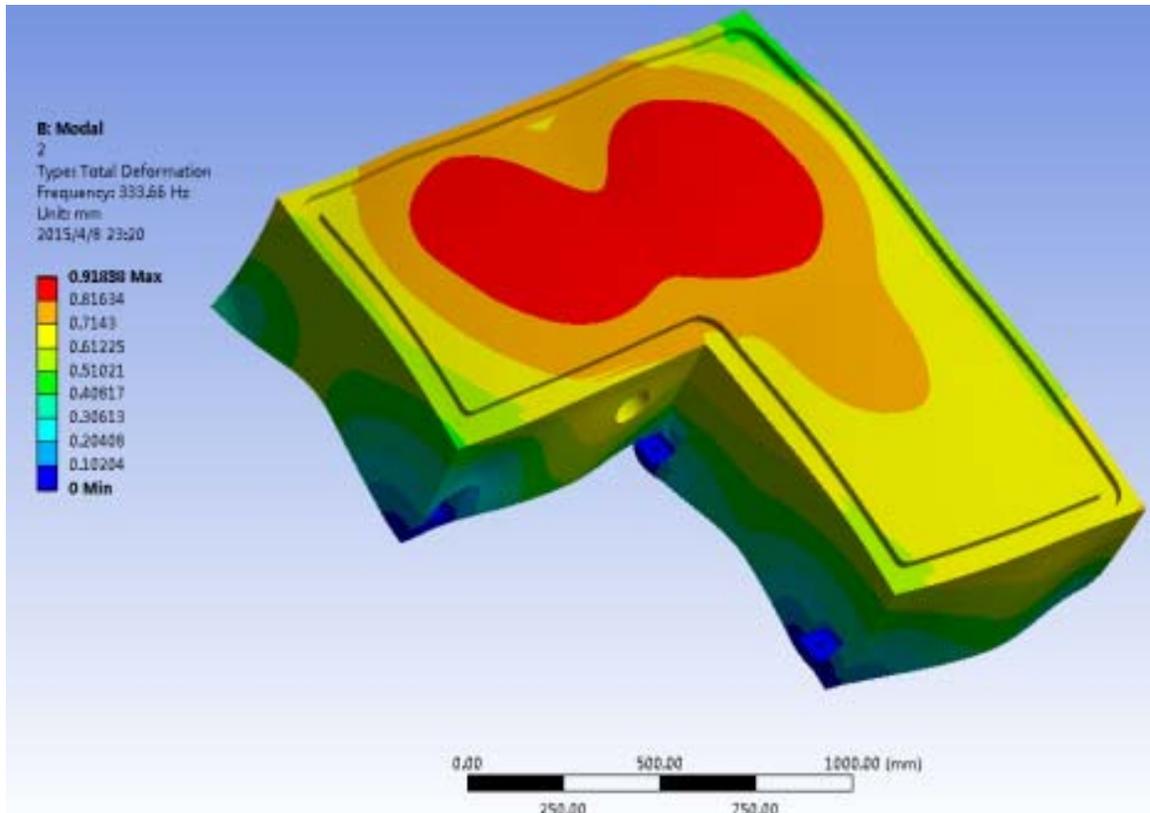


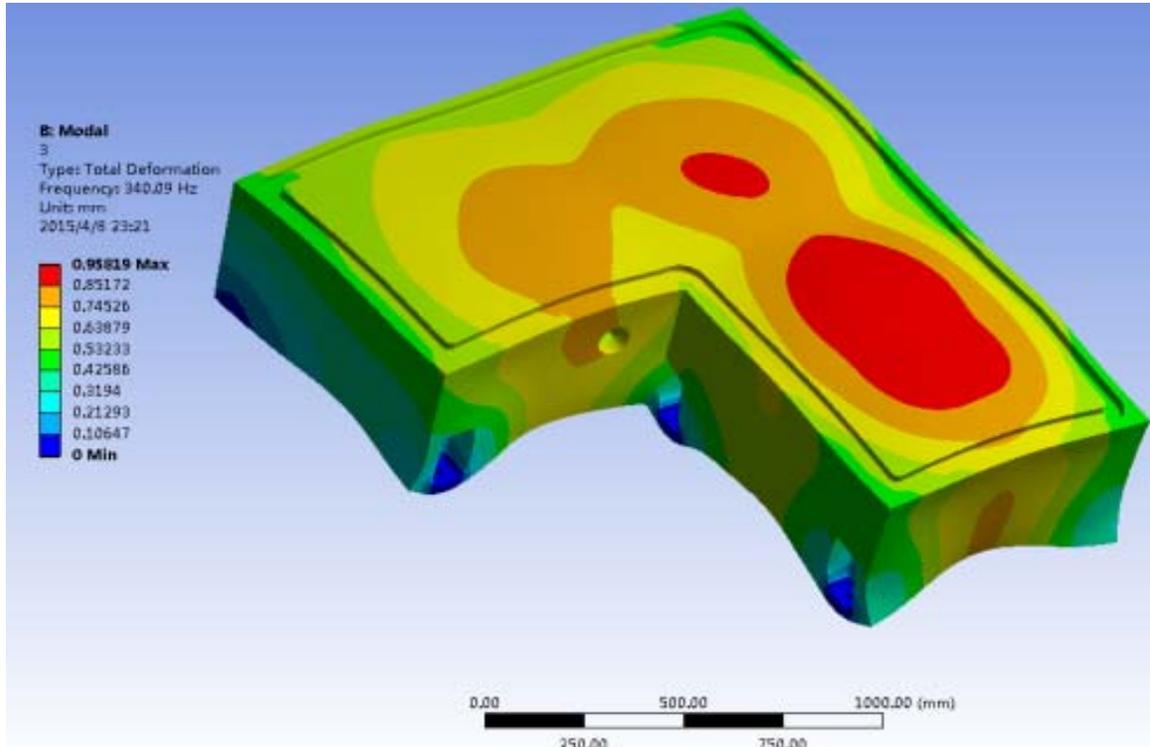
Fig. 2: The finite element model of food processing precision lathe bed grinder



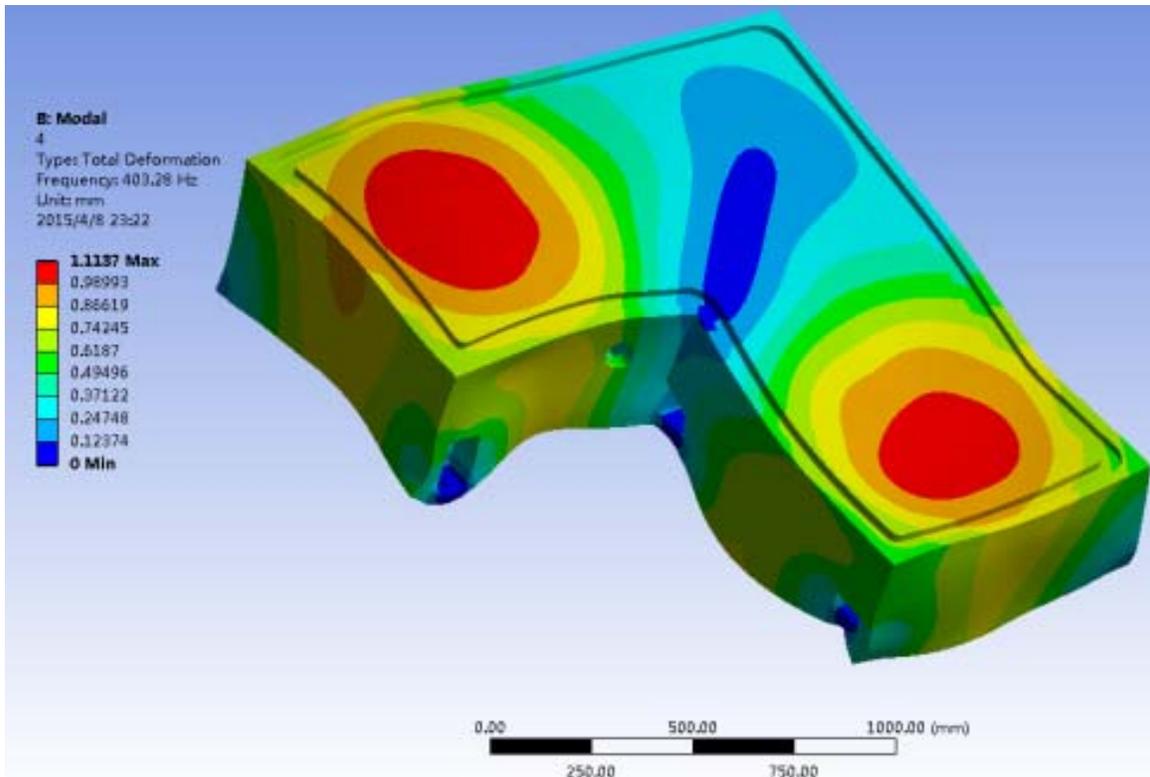
(a)



(b)



(c)



(d)

Fig. 3: 1, 2, 3, 4-order vibration modes; (a): The first order vibration mode; (b): Second-order vibration modes; (c): The third-order vibration mode; (d): Fourth-order vibration modes

Table 2: The modal analysis results

Order number	1	2	3	4
Frequency (Hz)	315.1	333.66	340.09	403.28
Order number	5	6	7	8
Frequency (Hz)	426.28	448	494.59	569.76

Using Modal module of ANSYS software, using Block Lanczos algorithm, the modal analysis for lathe bed model, its first four order modes is shown in Fig. 3, the first 8-order modal analysis results are shown in Table 2.

### CONCLUSION

This study describes the finite element analysis in food processing machine design applications and modal analysis and mathematical model of multi-freedom system was derived. Using ANSYS Workbench to L food processing precision grinding food processing machine lathe bed has carried on the modal analysis and each order modal are obtained. Through the simulation can indicate the direction for the actual food processing machine tool lathe bed structure design, reduce test times and shorten the design time.

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