Modal Analysis of Folding Frame

Li Hailiang, Sun Haitian, Yan Xiaoli, Liang Qi

(College of Engineering, Heilongjiang Bayi Agricultural University, Daqing 163319, Heilongjiang Province, China)

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Abstract: Study on folding frame to reduce the vibration in the process of transportation and work, the finite element model of folding frame was established by Pro/E and ANSYS Workbench and the modal analysis was performed, the vibration performance such as inherent frequency, vibration direction and extremum.etc were obtained by modal analysis module. The results show that, the structure design of frame is reasonable, resonance phenomenon will not occur as, the test results have a grast significance to improve the seeding precision seeder, prolong the service life of equipment.

1 Introduction

Seeding is the important link in the process of agricultural production, seeder is important equipment of agricultural machinery. Its working environment is complex, often accompanied with irregular vibration during working, serious when can cause bad phenomenon such as low working accuracy, fatigue life is short, and so on, so in order to guarantee the seeder has strong dynamic characteristic and adaptability,so it is necessary to made mode analysis for frame.

Currently, finite element analysis is often used to conducted the modal analysis for frame, Li Y M carried out the modal analysis and optimization design for header of combine-harvester, provided the design consideration for reducing the shake of header[1]. Xu L and Wang X Y conducted the modal analysis for corn seeder's frame, the results provided the reference for further suspension design[2]. Chen S R conducted the modal analysis for the frame of sprayer, the vibration of the frame was confirmed, then the project that frme won't resonance was obtained[3]. Wang X Y conducted the modal analysis for mountain miniature corn planter frame, the results have a significance for improving the stability and seeding uniformity of the machine[4]. Liu W X conducted the modal analysis for the frame of subsoiler, the results of the analysis provided the basis for improvement[5].

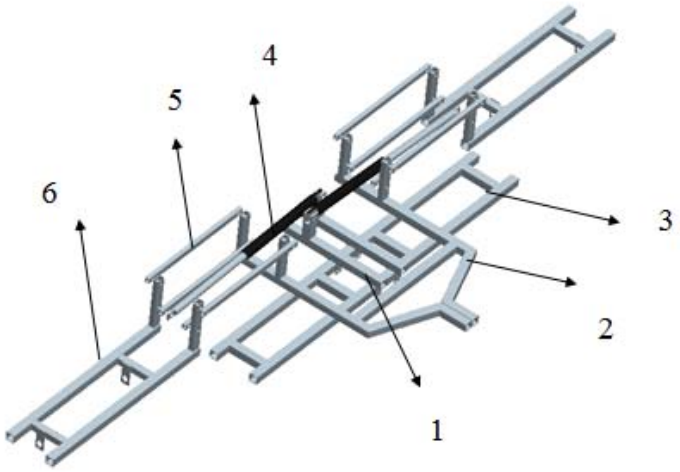
In this paper three-dimensional model was established by Pro/E, conducted the modal analysis by ANSYS Workbench, then compared the the results of the analysis and calculation of external excitation frequency to verify the rationality of the design. The dynamic characteristics analysis of frame is great importance for prevent the resonance phenomenon, improve equipment control stability and driving safety.

2 Finite element analyses

2.1 Model design

The frame of seeder mainly composed by main frame, vice-frames, hydraulic fixed bracket, four-bar fixed bracket, hydrocylinder and auxiliary members, was welded by square pipe and angle iron(density:$7.81\times 103 kg \cdot m^{-3}$, Poisson's ratio:0.30, elasticity modulus:$2.1\times 10^5 MPa$).

Parametric modeling and assembly simulation were conducted by Pro/E, ignore the influence of weld for vibration performance, some small chamfers, decorative parts, and auxiliary hole[6][7] to improve the running speed of modal analysis and the calculation accuracy, during modeling, three-dimensional model of folding frame is shown in figure 1 .



1.Hydraulic fixed bracket 2.Four-bar fixed bracket 3.Main frame 4.Hydrocylinder 5.Four-bar 6.Vice-frame

Fig.1 General assembly drawing of folding frame

2.2 Meshing

The basis of the finite element method is to use a collection of finite element to replace the original continuum, the finite element model is divided into discrete blocky that composed by a finite element through meshing.Adopt shell63 unit to meshing, the shape of gridding is quadrangle. Define the frame grid size of 50 mm, the meshing size of the position of stress concentration such as dowels etc was set is 10mm to improve the accuracy of the finite element analysis.The model was divided into 390935 units and 614641 nodes by meshing, frame finite element model is shown in figure 2.

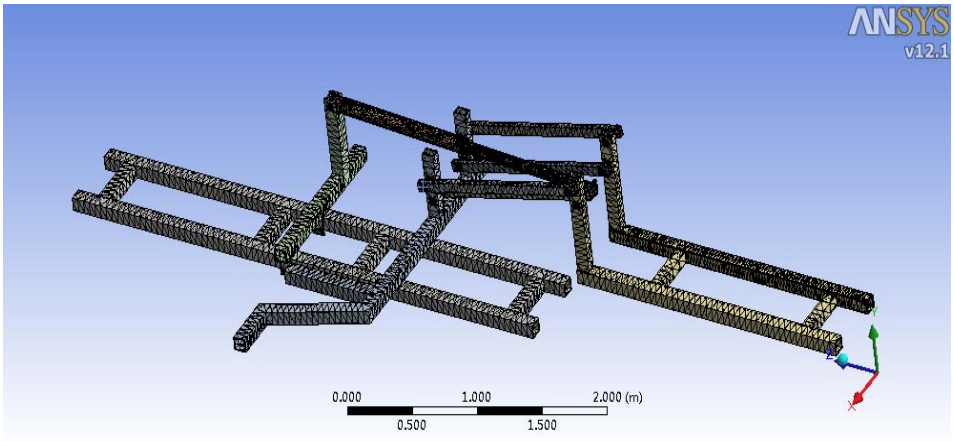


Fig.2 Finite element model of frame

2.3 Impose the load and constraint

Defining assembly and constraint relation has a direct influence on the veracity of finite element analysis, impose the constraint according to the assembly relationship. Restrained all degrees of freedom to fixed folding frame; The freedom in X direction was restricted by Displacement tool to avoid produce displacement in this direction[8].

Machine frame adopts three hanging articulated method, subject to integral rectangular frame structure, frame under load mainly includes the frame weight, seeding monomer gravity and seeding machine full load cases, the weight of the seed manure. Rack self-respect and seeding monomer weight can be in the software by adding a vertical downward acceleration of gravity on the ground (9.8 m/s^2), the weight of the seed manure can calculate according to the seed manure box size and the density of the seed manure is obtained, get the size of the frame by load and type as shown in table1.

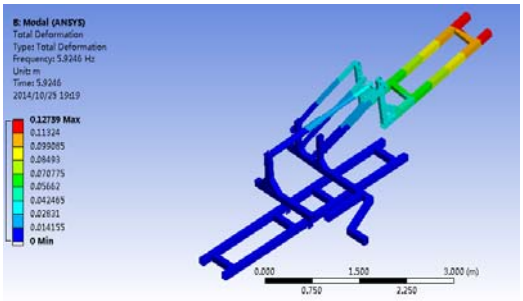
Table.1 Loads and applied methods of frame

Load	Parameter/N	Type
Vice frame and seeding monomer	6251.9	Concentrated load
Seed and fertilizer	3028.7	U distributed load

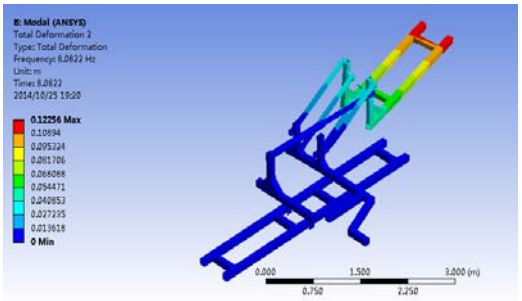
Calculation shows that frame under the load size of 9280.6 N, role of the vice frame, on the center of gravity of coordinates in the ANSYS Workbench to (1.1, 1.1, 3.19).In order to enhance the reliability of the simulation analysis, on the frame size of 10000 n, distal direction vertical downward load.

3 Modal analysis

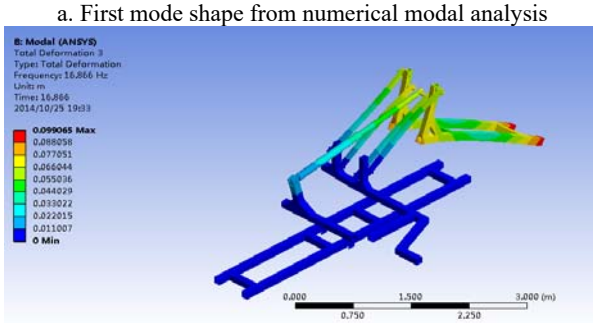
Modal analysis is used to determine the system, the vibration characteristics of the structure of the vibration order can be expressed as a linear combination of the inherent vibration mode, low order modes on the structure of the power influence is bigger than high order vibration mode,so before 6 order natural frequency are analyzed under the Modal module only to frame[9], it is concluded that the first six frequencies change corresponding vibration mode diagram, as shown in Fig 3.



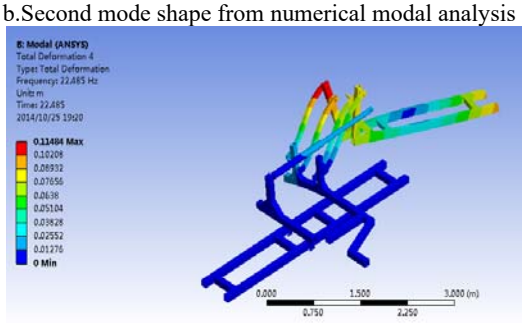
a. First mode shape from numerical modal analysis



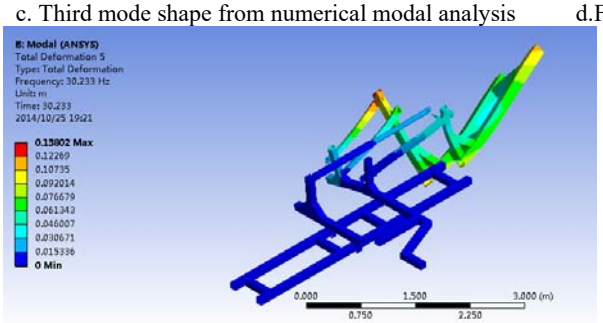
b.Second mode shape from numerical modal analysis



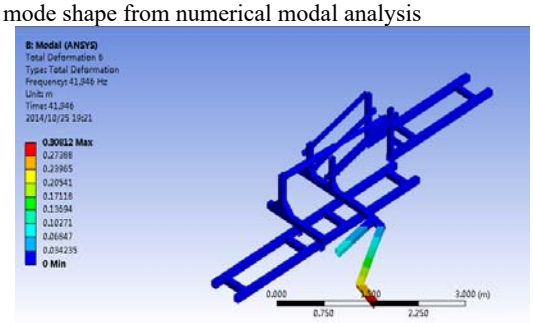
c. Third mode shape from numerical modal analysis



d.Fourth mode shape from numerical modal analysis



e. Fifth mode shape from numerical modal analysis



f.Sixth mode shape from numerical modal analysis

Fig.3 Mode shapes from numerical modal analysis

Through the modal analysis, got the information about frequency, direction, extremum, and mode of vibration, as shown in table 2

Tab.2 The front 6 order analysis results of the frame

Modal	Frequency /Hz	Principal direction	The minimum value location	The maximum value location	Main formation characteristics
1	5.4426	X-axis translation	Main frame	Vice-frame	Vice-frame bent in the Y direction
2	8.0822	Z-axis translation	Main frame	Vice-frame	Vice-frame bending in X axis direction
3	16.866	Y-axis translation	Main frame	Vice-frame	Vice-reverse rack in the Y direction
4	22.485	X-axis rotation mode	Main frame	Four bar folding mechanisms	Vice-frame torsion in X axis direction
5	30.233	Y-axis rotation mode	Main frame	Four bar folding mechanisms	Vice reverse rack in the Z axis direction
6	41.946	Z-axis rotation mode	Main frame	Four bar folding mechanisms	Four bar fixed bracket vibration in the Y direction

Modal analysis results shows that the frame's before 6 order modal distribution between 5.4 ~ 41.9 HZ frequency range, with the increase of the order number shows the tendency of increasing, and there is a big gap between the modal frequencies.Seeder frame main work under external motivation is divided into vibration excitation and pavement, through access to relevant production take an examination of documents, the planter working frequency excitation in 6 ~ 7Hz[10].Road surface can be determined by frequency formula (1) the highest vibration frequency, the calculation result is F = 26.4 Hz.

$$F=V/(3.6\lambda) \quad (1)$$

Where:：v—Speed of a motor vehicle，30km/h；

λ—The rough wavelength of road，0.32m；

Therefore, with the help of outside interference, avoid the natural frequency of the rack seeder working vibration frequency and excitation frequency highest road, effectively avoid the superposition of frame resonance occur. At the same time, by the frame vibration mode can figure that the vibration of the frame mainly occurs in the vice frame, so prone to fatigue damage or crack on the vice-frame, therefore in the process of making it is necessary to strengthen its welding technology.

4 Conclusions

Based on the analysis of 2 BMZ-13 gas suction no-till precise seeder rack, on the basis of the structure and characteristics of 3D modeling software Pro/E is adopted to establish the frame of the 3 d model, conducted mode analysis by ANSYS Workbench, determined the frame first six order modal characteristics of natural frequency and vibration mode, results show that the first six natural modal range from 5.9 to 5.9 HZ, avoids the work highest vibration frequency 6 ~ 7 HZ, and the road excitation frequency F = 26.4 HZ,showed that the models of seeder rack has good dynamic characteristics.

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