Finite Element Analysis of Stripping Roll of Peanut Picker Based on ANSYS Workbench

Jicheng li[1, a], Yuefang Luo[1, b] and Lin Guo[2, c*]

[1] College of Mechanical and Electrical Engineering, Yunnan Technology and Business University, Kunming, China

[2] College of Mechanical and Electrical Engineering, Yunnan Agricultural University, Kunming, China

[a]981666199@qq.com, [b]luoyuefang@126.com, [c]1265120@qq.com

Keywords: Peanut Picker; Static Analysis; Mode Analysis

Abstract: Peanut picker is a common peanut harvesting machine. The stripping roll is one of the important parts of the peanut picker. Its stability is an important guarantee for the normal operation of the picker. In this paper, the static and modal analysis of a certain type of stripping roll is carried out by using finite element method. The results show that: under rated working conditions, the maximum equivalent stress of the stripping roll is 52.285 MPa, which is much less than 400 MPa, and material yield failure will not occur. According to modal analysis, the frequency of external interference of the stripping roll can not be close to 56.26 Hz, 57.52 Hz, 60.00 Hz, 118.31 Hz, 144.50 Hz and 147.45 Hz, otherwise resonance hazards will easily occur. Through the analysis, the mechanical characteristics of the stripping roll are reasonably analyzed, and the basis for the follow-up optimization design is provided.

Introduction

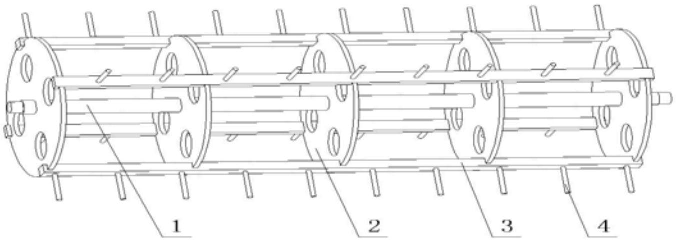
Peanut is an important oil crop in China. It has a wide planting area. With the continuous improvement of agricultural mechanization technology in China, peanut picker has gradually become mature. stripping roll is one of the important parts of peanut picker. Its function is to separate peanut fruit from peanut stem by high-speed rotation. When the stripping roll roll rotates at high speed, its structure will bear large centrifugal force and load, which will easily cause failure and safety problems.

In this paper, ANSYS Workbench finite element analysis software is used for static analysis and modal analysis of a certain type of stripping roll, the data of stress, deformation and modal are obtained. According to the simulation data, the safety of the stripping roll is analyzed, which provides a basis for the subsequent optimal design of the stripping roll.

Analytical Model

The stripping roll is generally composed of axle, axle disc, tooth base and tooth. As shown in figure 1, the axle disc is fixed on the axle, the tooth base is fixed on the axle disc, and the tooth base is fixed on the tooth base. The material of the stripping roll is structural steel, and its main characteristic parameters are shown in table 1.

  DOI: 10.25236/icme.2019.025



1- axle；2- axle disc；3- tooth base；4- tooth

Figure 1. Structural schematic diagram of stripping roll

Table 1 Material Characteristics

Material Name	Modulus of Elasticity/GPa	Poisson ratio	Yield strength/Mpa	Tensile strength/Mpa	Density $kg{\cdot}m^{-3}$
QSTE420T	200	0.3	400	440	7850

Static Analysis

Static analysis is the most commonly used analysis method for mechanical structure. When the mechanical structure keeps steady state, it can be used to analyze the structural characteristics of machinery[1].

Pretreatment of Static Analysis. According to the characteristic parameters of the stripping roll of the research object, a three-dimensional parameterized model is established by using Solidworks, and then the three-dimensional model is imported into ANSYS Workbench. Bearing support is applied at both ends of the stripping roll axle, and then the rotational speed of the roll is set to 80 rad/s, as shown in figure 2. The material model shown in Table 1 is established in ANSYS Workbench material library, and the material of the stripping roll model is set as the material model.

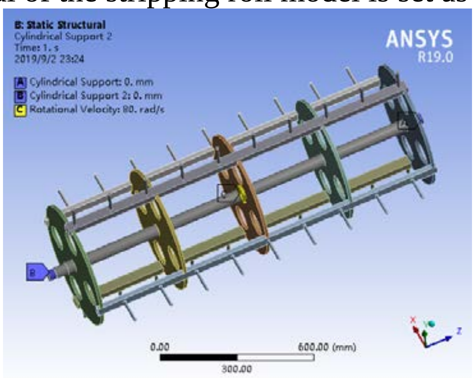


Figure 2. Loads and constraints

Static Analysis Results. After meshing, the analysis model is solved and calculated, and the equivalent stress and total deformation cloud of the stripping roll are obtained. figure3 is the equivalent stress cloud of the stripping roll. From the graph, it can be seen that the maximum equivalent stress occurs at the location of the axle disc and the tooth base, which is located between the two axle discs. The maximum equivalent stress is 52.285 MPa, which is far less than 400 MPa. The failure of material will not occur, and the stability of the stripping roll can be improved by adding reinforcement ribs at the higher stress.

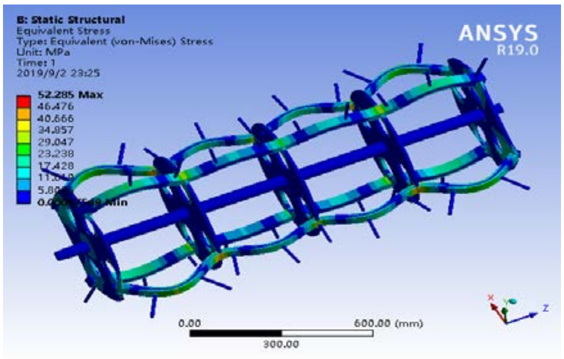


Figure 3. Equivalent stress nephogram

Figure 4 is the total deformation cloud of the stripping roll. From the figure, it can be seen that the largest total deformation occurs in the tooth seat between the two axle discs. The largest total deformation is 0.159 mm. Compared with the overall size of the stripping roll, the deformation is smaller, which can ensure the normal operation of the peanut picker. The deformation of the middle three circles is small, and the weight of the structure can be reduced by hollowing out more materials.

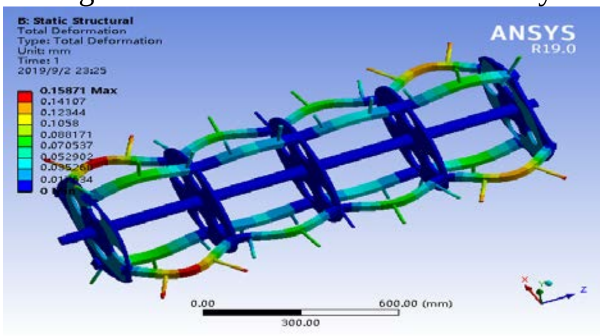


Figure 4. Total deformation nephogram

Analytical Model

Modal analysis is one of the most commonly used methods to study mechanical vibration. Modal is the inherent characteristic of mechanical structure. Each mechanical structure has multiple modes, and the modes are arranged from small to large. For general mechanical structures, the vibration frequency of low-order modes is very easy to reach and cause failure. This paper analyses and calculates the first six modes of the stripping roll[2].

Pretreatment of Modal Analysis. In ANSYS Workbench, a modal analysis project is established, and the results of static analysis are taken as the analysis conditions of modal analysis. This analysis method can more accurately analyze the modal situation of the stripping roll under working conditions, and set the order of modal analysis to six orders[3].

Modal Analysis Results. By solving and calculating, the first six modes of the stripping roll are obtained. The vibration frequencies of the first six modes are shown in table 2. From the table, it can be seen that the vibration frequencies of the first six modes range from 56.26 Hz to 147.45 Hz. That is to say, for low-frequency vibration, if the frequency of external interference is just similar to the vibration frequencies of the first six modes,it will cause resonance hazard.

Table 2 Modal Frequency

Step	Frequency/Hz
1	56.26
2	57.52
3	60.00
4	118.31
5	144.50
6	147.45

Figure 5 is the first modal nephogram of the stripping roll. The vibration frequency of the first-order modal is 56.24 Hz. The maximum deformation occurs in the part of the stripping teeth. The maximum deformation is 6.25 mm, while the deformation of the shaft, the shaft and the tooth seat is small.

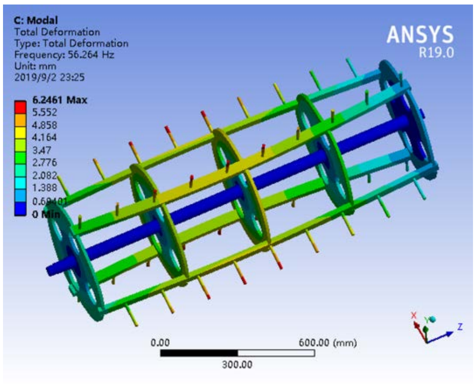


Figure 5. The first modal nephogram

Figure 6 is the second modal cloud of the stripping roll. The second-order modal vibration frequency is 57.21 Hz. The maximum deformation occurs in the middle of the stripping roll. The maximum deformation value is 4.05 mm.

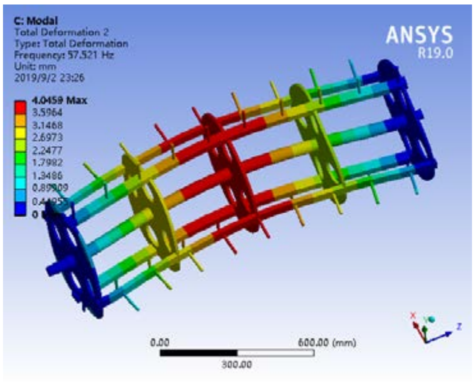


Figure 6. The second modal nephogram

Figure 7 shows the third modal cloud of the stripping roll. The vibration frequency of the third-order modal is 60.00Hz. The maximum deformation occurs in the middle of the stripping roll. The maximum deformation value is 4.06mm.

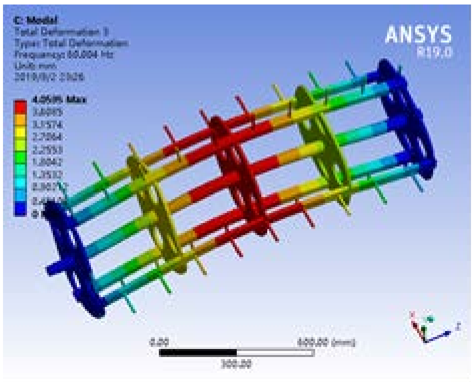


Figure 7. The third modal nephogram

Figure 8 is the fourth modal nephogram of the stripping roll. The vibration frequency of the fourth-order modal is 118.31Hz. The maximum deformation occurs on both sides of the stripping roll. The maximum deformation value is 7.38mm.

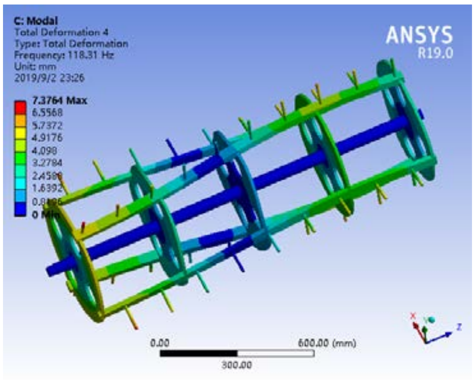


Figure 8. The fourth modal nephogram

Figure 9 is the fifth modal nephogram of the stripping roll. The vibration frequency of the fifth-order modal is 144.5Hz. The maximum deformation occurs on the two opposite teeth of the stripping roll. The maximum deformation value is 5.51mm.

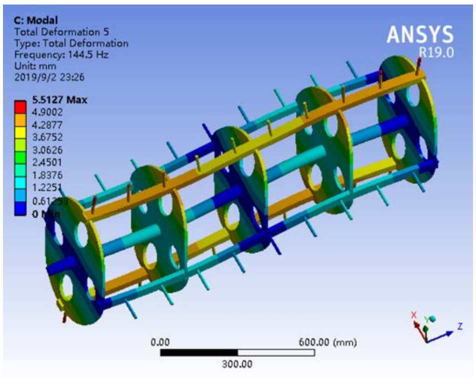


Figure 9. The fifth modal nephogram

Figure 10 is the sixth modal nephogram of the stripping roll. The vibration frequency of the sixth-order modal is 144.5Hz. The maximum deformation occurs on the axle disc and the stripping teeth of the stripping roll. The maximum deformation value is 4.25mm.

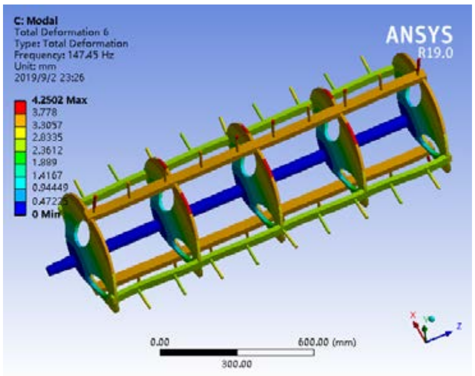


Figure 10. The sixth modal nephogram

Analytical Model

Stripping roll is one of the important parts of peanut picker. Its stability is an important guarantee for the normal operation of the picker. Through static analysis and modal analysis, the following conclusions are obtained.

(1) Under rated working conditions, the maximum equivalent stress of the stripping roller is 52.285 MPa, which is much less than 400 MPa, and no material yield failure will occur.

(2) According to the modal analysis, the frequency of external interference of the stripping roller can not be close to 56.26 Hz, 57.52 Hz, 60.00 Hz, 118.31 Hz, 144.50 Hz and 147.45, otherwise resonance hazards will easily occur.

References

[1]. WANG Lihe, ZHAO Yonglai, CUI Hongmei, et al. Static Analysis and Lightweight Design of Subsoiler Frame Based on ANSYS Workbench[J]. Journal of Chongqing University of Technology (Natural Science), 2019, 33(2) : 87- 93.

[2]. S. P. Zhu,Q. Lei,Q. Y. Wang. Mean stress and ratcheting corrections in fatigue life prediction of metals[J]. Fatigue & Fracture of Engineering Materials & Str. 2017 (9).

[3]. Hungsun Son,Hae-Jin Choi,Hyung Wook Park. Design and dynamic analysis of an arch-type desktop reconfigurable machine[J]. International Journal of Machine Tools and Manufacture. 2010 (6).