



Design of Elevated Silkworm Frame Leaf Feeding System

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Abstract. With the development of silkworm economy in Yizhou, the trend of intensive sericulture is becoming more and more obvious, and the demand for agricultural machinery and equipment in sericulture is increasing. Therefore, in order to correspond to the intensive elevated sericulture road in Yizhou, there are higher requirements for leaf feeding system. Based on the research of leaf feeding system and its similar devices at home and abroad, the existing mechanical equipment is optimized. This subject designs an elevated silkworm frame leaf feeding system. Mainly through the analysis of the existing automatic silkworm frame leaf feeding system, aiming at the problem of uneven leaf distribution of the existing automatic silkworm frame leaf feeding system, the leaf distribution uniformity of different structures is studied, The optimized and improved design scheme is obtained. Finally, PLC is used for program development. After optimizing and improving the design, the mulberry spreading mechanism is changed to roller feeding mechanism, which significantly improves the leaf spreading uniformity of the elevated silkworm frame leaf feeding system and reduces the labor force. This topic mainly analyzes the structure of the existing automatic silkworm frame leaf feeding system, and finally completes the optimization and improvement design of the structure through the UG modeling and analysis results.

Keywords: Elevated sericulture · PLC · Optimize and improve the design · Roller feeding mechanism

1 Introduction

In the economic system of Yizhou District of Hechi City, sericulture economy occupies a very important position. The mulberry garden area and cocoon yield of Yizhou District maintain the first position in the county all year round. Intensive sericulture is the development trend of modern sericulture economy. It is very necessary to develop large-scale and intensive sericulture production. Intensive sericulture can solve the problems of lack of sericulture labor force, masculinity and aging in rural areas. Silkworm rearing in Yizhou is basically a ground silkworm rearing mode, which requires farmers

to prepare a large area of production plants, and the utilization rate of space is not high. Yizhou District lacks technological innovation on the road to intensive sericulture. There are few strong silkworm automation machinery R & D institutions in Yizhou district. In terms of mulberry planting and sericulture, the technical innovation problems of efficient integration of supporting automation technology, labor-saving technology and machines and tools are still in a difficult stage [1].

2 Scheme Design of Elevated Silkworm Frame Leaf Feeding System

The traditional leaf feeding system only sprinkles mulberry leaves on the silkworm cultured on the ground of the plant. This ground silkworm breeding mode covers a large area and has low utilization rate of space. In order to improve the space utilization of silkworm breeding, the intelligent silkworm breeding system with elevated silkworm frame was put into operation. As shown in Fig. 1, the silkworm rearing frame is removed from the silkworm frame overhead through the silkworm frame lifting transportation system, and then transported to the leaf feeding system and disinfection system. After the completion of leaf feeding and disinfection, it is transported back to the overhead. This paper studies the silkworm frame leaf feeding system used in conjunction with silkworm frame transportation system and disinfection system in a complete set of elevated intelligent silkworm rearing system. Silkworm frame leaf feeding system plays an important role in the whole elevated intelligent silkworm rearing system. Its function is to evenly lay mulberry leaves in the silkworm rearing frame transported from the elevated, so as to achieve good feeding effect [2].

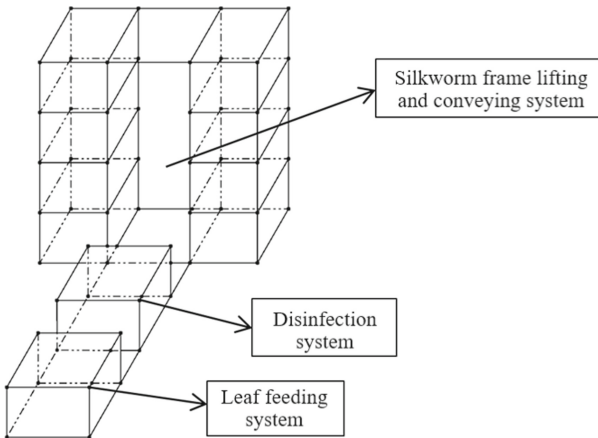


Fig. 1. Intelligent silkworm rearing system with elevated silkworm frame

The working process of the elevated silkworm frame leaf feeding system is very simple. Firstly, the feeding conveyor belt of the mulberry feeding mechanism transports the mulberry leaves of the two silkworm frames to the mulberry storage mechanism,

waits for the two silkworm frames with silkworms to reach below the output mechanism, rolls the two roller shafts of the roller feeding device of the mulberry laying mechanism, and the silkworm rearing frame moves at a certain speed, The mulberry leaves in the mulberry storage mechanism are evenly scattered in the silkworm rearing frame to feed the silkworm.

The mulberry feeding mechanism transports the amount of mulberry leaves of two silkworm frames to the mulberry storage mechanism each time. The amount of mulberry leaves in the two silkworm frames changes according to the age of the silkworm and the number of days raised in a single age. For example, the amount of mulberry leaves given to the silkworm in the first two days and the second two days of the 5th instar silkworm should be strictly controlled, and the silkworm should have enough mulberry leaves to eat in the middle time. After clicking the mulberry spreading start button, when the silkworm rearing frame triggers the first limit switch, the PLC control system obtains the signal, sends the operation command to the mulberry conveying belt and transmits the mulberry leaves to the mulberry storage mechanism. When the sensor in the mulberry storage mechanism detects that the amount of mulberry leaves is met, the PLC control system obtains the signal, sends the stop operation command to the mulberry conveying belt and suspends the transportation of mulberry leaves to the mulberry storage mechanism [3, 4].

The mulberry storage mechanism is divided into two parts. The mulberry storage mechanism before the mulberry delivery mechanism is used for the storage of a large number of mulberry leaves, and the mulberry storage mechanism above the mulberry spreading mechanism is used to connect the mulberry delivery mechanism and the mulberry spreading mechanism, and plays a buffer role between the mulberry delivery mechanism and the mulberry spreading mechanism. After clicking the mulberry spreading start button, when the silkworm rearing frame reaches the lower part of the mulberry spreading mechanism and triggers the second limit switch, the PLC control system obtains a signal and sends a command to open the diaphragm to the mulberry storing mechanism, so that the mulberry leaves stored in the mulberry storing mechanism fall to the roller feeding device of the mulberry spreading mechanism, When the silkworm rearing frame reaches the lower part of the mulberry spreading mechanism and triggers the third limit switch, the PLC control system obtains the signal and sends the closing diaphragm command to the mulberry storing mechanism to form a buffer between the mulberry feeding mechanism and the mulberry spreading mechanism.

3 Structure and Transmission Design of Blade Feeding System

3.1 Structural Design of Mulberry Feeding Mechanism

The high-low stand is mainly used as the support frame of the mulberry feeding mechanism [5]. The baffles on both sides of the conveyor belt are mainly used to prevent the mulberry leaves from falling from both sides of the conveyor belt when transporting the mulberry leaves. The conveyor belt is mainly used to transport the mulberry leaves to the mulberry storage mechanism. The conveying roller shaft is divided into driving roller shaft and driven roller shaft. The driving roller shaft is connected with the motor to transmit power for the conveyor belt. The driven roller shaft and the driving roller shaft

support the conveyor belt. The motor is connected to the drive roller shaft to provide power for the conveyor belt. As shown in Fig. 2.

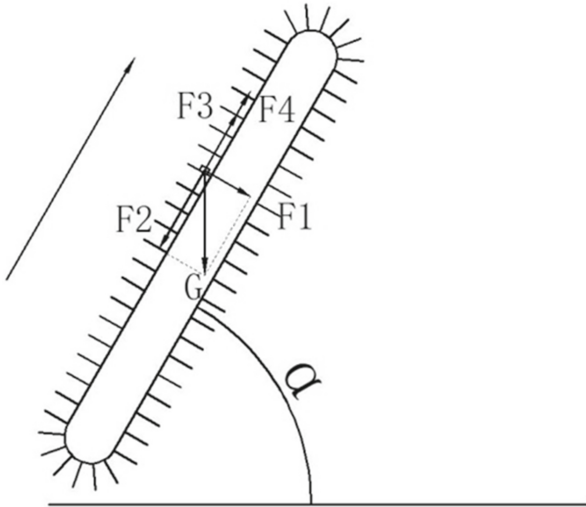


Fig. 2. Conveyor belt movement diagram

3.2 Structural Design of Mulberry Storage Mechanism

The problems needing attention in feeding silkworm mulberry leaves are:

- (1) Fresh mulberry leaves are very easy to dry, while silkworms don't eat dry mulberry leaves. Silkworms only like fresh mulberry leaves;
- (2) Mulberry leaves fed to silkworms must be free of ash and moisture;
- (3) The amount and time of feeding mulberry leaves to silkworms need to be determined according to the demand of silkworms for mulberry leaves and the time of starvation.

Therefore, before putting the mulberry leaves into the mulberry storage mechanism, the mulberry leaves must be washed and then dried. In summer and autumn when the temperature is high and the climate is dry, you can add 5 ml fermentation broth to a kilogram of water, and then spray it to wet the mulberry leaves, which can keep the mulberry leaves for a whole day.

The movement diagram of the diaphragm of the mulberry storage mechanism is shown in Fig. 3 below.

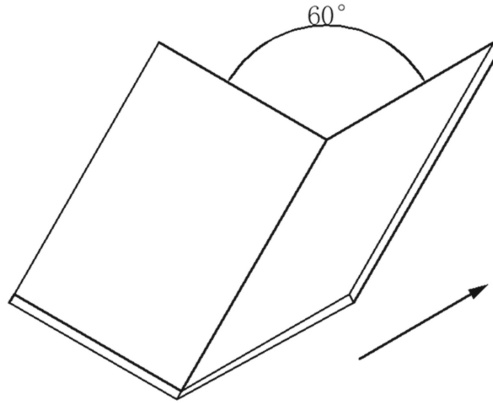


Fig. 3. Diagram of diaphragm movement

There are two inward inclined diaphragms between the mulberry storage mechanism above the mulberry spreading mechanism and the mulberry spreading mechanism. When the two diaphragms are combined, they are used to separate the mulberry storage mechanism and the mulberry spreading mechanism, so that the mulberry leaves will not enter the mulberry spreading mechanism directly after entering the mulberry storage mechanism from the mulberry feeding mechanism, so as to play a buffer role [6]. When mulberry leaves directly enter the mulberry spreading mechanism from the mulberry feeding mechanism, a small amount of mulberry leaves may fall directly from the mulberry spreading mechanism into the silkworm rearing frame, thus affecting the uniformity of mulberry spreading. After the two diaphragms are opened, make the falling position of mulberry leaves face between the opposite roll shafts of the mulberry spreading mechanism, so that when the mulberry leaves fall from the mulberry storage mechanism to the mulberry spreading mechanism, there will be no mulberry leaves left on both sides of the opposite roll shafts of the mulberry spreading mechanism. Adding a partition between the mulberry storage mechanism and the mulberry spreading mechanism is conducive to improve the uniformity of mulberry spreading. In order to store enough mulberry leaves and cooperate with the mulberry spreading mechanism, the length of the two diaphragms is designed as 0.94 m and the inclination angle is designed as 0.48 m. One fixed diaphragm is 0.48 m wide and the other movable diaphragm is 0.8 m wide. A gear rack is installed on the movable diaphragm, and the transmission of the gear rack drives the movement of the diaphragm.

4 Transmission Design

Given the belt speed and the required circumferential force of the transmission drum, the shaft power of the transmission drum can be calculated as:

$$P_A = F_u \cdot v \quad (1)$$

The motor driving power calculated according to formula (1) is:

$$P_m = k_0 \cdot k \cdot P_A \quad (2)$$

In this design, the diaphragm transmission scheme of the mulberry storage mechanism adopts gear strip transmission. The gear is made of 45 steel or 41Cr4 and quenched and tempered, and the surface hardness shall be above 56HRC. In order to reduce the mass, the shell is die cast with aluminum alloy. Due to the low speed of the steering gear, it is a general machinery, so grade 7 accuracy is selected.

Selection of modulus m and number of teeth Z :

Taking the pinion module $M = 4$, the increase of the number of teeth of the gear can increase the coincidence degree and improve the stability of transmission. However, for this design, the strength of the gear is mainly considered. Moreover, in this design, the smaller the space occupied by the gear rack, the better the tooth surface hardness. Therefore, the smaller the number of teeth of the pinion is, the more suitable the number of teeth is. If the number of teeth is reduced, the module can be increased, the bending strength of the gear can be improved. In this design, the number of teeth of the pinion is $z = 20$.

The design speed of the rack is 100 mm/s, and the rotation speed of the gear is 100 mm/s, i.e. $v = 100$ mm/s:

$$V = \frac{\pi dn}{60} \quad (3)$$

$$d = mz \quad (4)$$

When the pressure angle increases, the tooth thickness of the dangerous section of the tooth increases and the bending force arm decreases. Therefore, the strength of the tooth root increases, but with the increase of the pressure angle, the fillet radius of the tooth root decreases, the stress concentration factor increases, and the coincidence degree also decreases, so that the upper boundary point of the single pair of teeth meshing area is far away from the tooth root, and the bending force arm increases, which is unfavorable to the bending strength.

5 Analysis and Optimization of the Key Structure of Mulberry Branch Crusher

5.1 Introduction to Finite Element Method

The finite element analysis process is mainly divided into three steps, namely pre-processing, solution and post-processing. The general flow of each step is shown in Fig. 4:

At present, finite element analysis software mainly includes ANSYS, ABAQUS, simulation and other software. This design uses simulation to carry out finite element simulation analysis and optimization of the key parts of mulberry twig crusher. Simulation has different packages to realize various analysis functions, mainly including static analysis, thermal stress analysis and modal analysis.

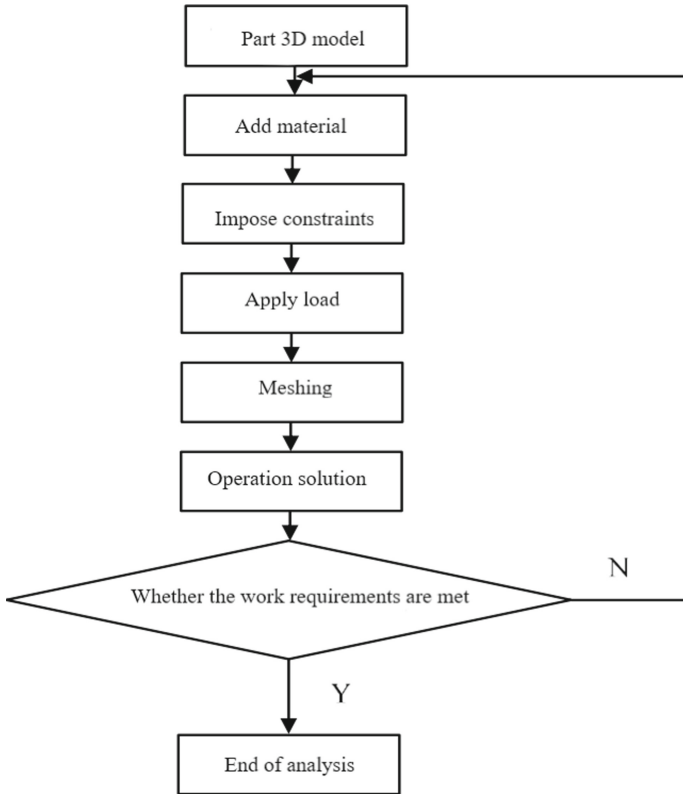


Fig. 4. Finite element analysis flow chart

5.2 Static Analysis of Cutter

According to relevant data, the force exerted by mulberry branches on the cutter can be divided into radial and axial directions, and the resultant force on the cutter can be calculated according to formula 5:

$$F_{\max} = \sqrt{(F_{x\max})^2 + (F_{y\max})^2} \times \cos 31^\circ \quad (5)$$

Open the established cutter model and create a new calculation example. You will see the analysis options such as static stress analysis, frequency, thermal, linear dynamic, etc. This analysis only studies whether the strain, stress and displacement of the cutter meet the strength requirements. Bei chooses the static stress analysis and names it “cutter static stress analysis” to define the material properties. For engineering analysis in any field, materials must be defined, otherwise finite element analysis cannot be carried out. The defined material can be obtained from the solid works material library, or the material can be defined in the modeling module in advance. The material of the cutter is defined as “65Mn steel”.

Since the cutter is fixed by bolts in practice, you can select the fixed geometry in simulation, and the schematic diagram of adding constraints is shown in Fig. 5.

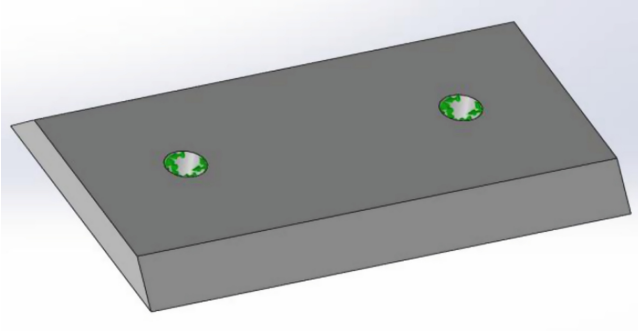


Fig. 5. Schematic diagram of cutter constraint

Apply a load on the blade of the cutter. According to the result, the cutter receives about 4493.8n at the blade. The stress diagram of the cutter is shown in Fig. 6.

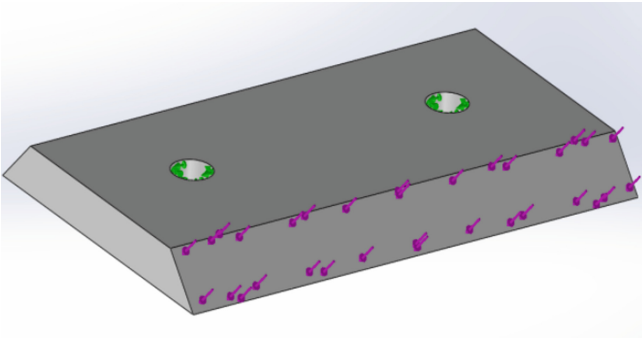


Fig. 6. Loading diagram of cutter

The selected grid type is standard grid. The higher the accuracy of mesh generation, the higher the requirements for computer configuration. After comprehensive consideration, set the size of the mesh to 5 mm and the tolerance to 0.25 mm. The mesh generation effect is shown in Fig. 7.

After solving the example, the stress, displacement and strain distribution diagram is obtained. The stress distribution is shown in Fig. 8. It can be seen from the figure that the maximum stress is $1.329 \times 10^8 \text{ N/m}^2$, the maximum yield force that the cutter can bear is $4.3 \times 10^8 \text{ N/m}^2$, the maximum stress is less than the maximum yield stress, then the design meets the requirements from the point of view of stress. The displacement distribution diagram is shown in 8. After receiving 4493.8 N force, the maximum displacement of the cutter is $3.299 \times 10^{-2} \text{ mm}$, the maximum deformation occurs at the middle and lower edge of the blade surface, and the minimum deformation is almost 0, which occurs at both sides of the blade surface (Fig. 9).

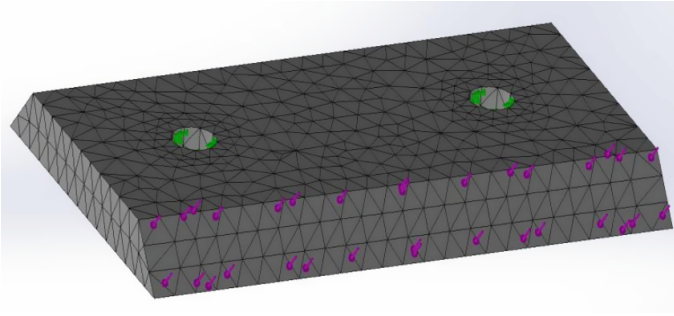


Fig. 7. Cutter mesh rendering

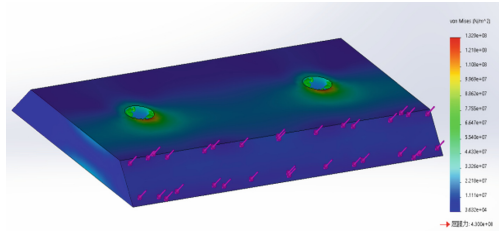


Fig. 8. Cutter stress distribution diagram

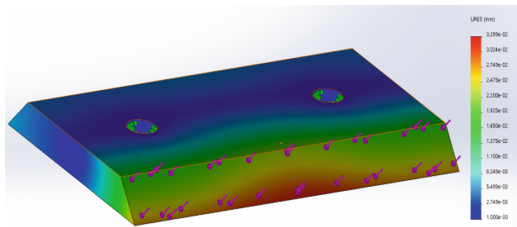


Fig. 9. Cutter displacement distribution

The strain distribution diagram is shown in 10, and the maximum cutter strain is 4.703×10^{-4} , the minimum strain is 2.206×10^{-7} . It can be seen from the figure that the magnitude of the strain is directly proportional to the stress (Fig. 10).

5.3 Static Analysis of Hammer Frame Plate

Open the established hammer frame plate model and create a new example in simulation. It only studies whether the strain, stress and displacement of the cutter meet the strength requirements, so the static stress analysis is selected, and the analysis is named “static stress analysis of hammer frame plate”.

The defined material is obtained from the solid works material library, or the material can be defined in the modeling module in advance. The material of the hammer frame plate is defined as “Q235 steel”.

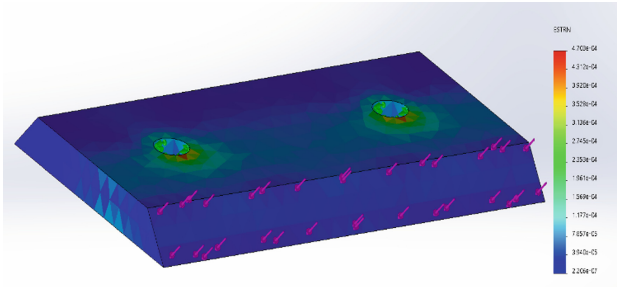


Fig. 10. Cutter strain distribution

The hammer frame plate is fixed by the main shaft and the pin shaft, and then select the fixed geometry to simulate the constraints. See Fig. 11 for the schematic diagram of adding bundles to the hammer frame plate.

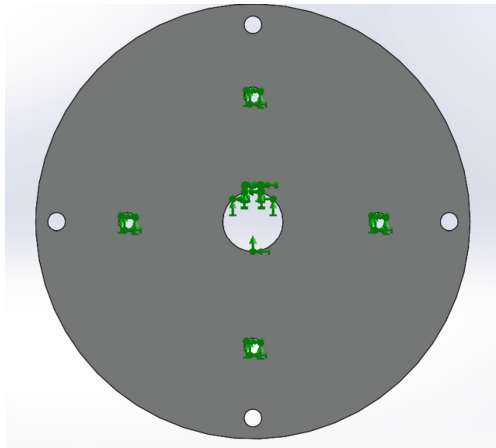


Fig. 11. Schematic diagram of restraint applied by hammer frame plate

Apply load on the four pin holes. According to the calculation, a single pin hole receives about 0.705 mpa. The load diagram of the cutter is shown in Fig. 12.

The mesh type selected in simulation is standard mesh. The higher the accuracy of mesh generation, the closer the results are to reality. Considering the computer performance and the actual situation, the size of the mesh is set to 8 m with a tolerance of 0.4 mm. The mesh generation effect is shown in Fig. 13.

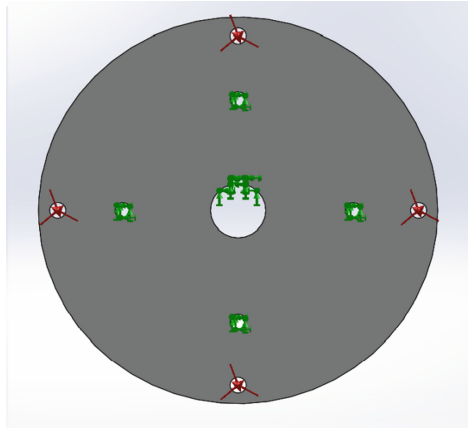


Fig. 12. Loading diagram of hammer frame plate

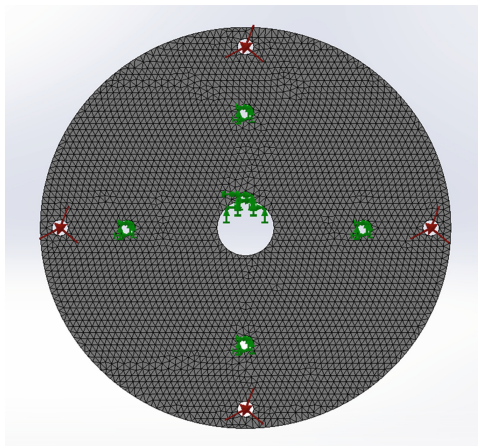


Fig. 13. Rendering of grid division of hammer frame plate

The strain distribution diagram is shown in Fig. 14, and the maximum value of cutter strain is 5.104×10^{-6} , the minimum strain is 3.656×10^{-10} . It can be seen from the figure that it is related to the stress distribution. The strain is larger where the stress is larger, and the strain is smaller where the stress is smaller.

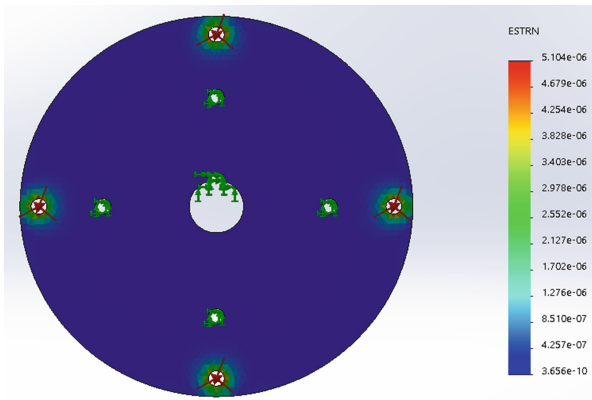


Fig. 14. Strain distribution diagram of hammer frame plate

6 Conclusion

The elevated silkworm frame leaf feeding system designed in this paper is aimed at the silkworm breeding mode in Yizhou District, Hechi City, Guangxi, which can develop faster to the intensive silkworm breeding mode, and quickly convert the ground silkworm breeding mode to the elevated silkworm breeding mode, which can make efficient use of rural resources in Yizhou District and improve the efficiency of silkworm breeding in Yizhou district. Because the existing overhead automatic silkworm rearing machinery and equipment are relatively few, there are still some problems in the existing overhead automatic silkworm rearing machinery and equipment. Therefore, it is necessary to study and design the overhead silkworm frame leaf feeding system. In the continuous research and design, the elevated silkworm frame leaf feeding system designed in this subject can basically meet the expected design requirements.

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