Simulation Research on Mechanical Properties and Crack Growth of Tobacco Leaf

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Abstract

Aimed at the problem of crack propagation of tobacco leaves subjected to (type I) tensile force under specific conditions. This paper mainly discusses whether tobacco stem can inhibit the crack propagation. After temperature and humidity treatment of the selected tobacco samples, an electronic universal testing machine was used to conduct fracture tensile test of tobacco leaves. Through the simulation analysis of the type I crack propagation of tobacco slices, sections of tobacco stems and whole tobacco leaves, the graphs of force variation with time and stress-strain curves were obtained. The inhibiting effect of tobacco stem on crack was verified by comparison and analysis. The results showed that the tobacco stem did inhibit the crack propagation in the process of crack propagation.

Introduction

• Tobacco threshing process is a complicated, time-varying process with randomness, uncertainty, and highly nonlinear characteristics. The structure of sheet tobacco is an important index to measure the quality of threshing leaves.

• The three main factors that affect the quality of the leaves are the physical characteristics of the leaves, the equipment performance and the technological parameters of the threshing process.

• Li Yuefeng, et al conducted experiments on the influence of different temperature and humidity on the quality of threshing, and the results showed that increasing the temperature and moisture content of the original tobacco appropriately before threshing is beneficial to improve the threshing quality.

• Luo Fuwei, et al concluded through experiments that the tensile strength of tobacco leaves increased with the increase of moisture content before the moisture content was 18%, reached the maximum value when the moisture content was 18%, and then gradually deteriorated with the increase of moisture content. The temperature of tobacco leaves mainly affects the flexibility of tobacco leaves. Low temperature increases the brittleness and causes serious crushing during threshing. At the same time, it will increase the number of leaves in the stem after leaf beating and reduce the percentage of pieces; When the temperature is too high, the threshing efficiency will also be affected, and the repeated threshing rate will be low and the material will be easily blocked; The final analysis compares that the breaking rate of tobacco leaves is highest when the temperature of tobacco leaves is around 50°C. Many scholars have conducted research on the threshing stage, but they are all based on experiments, and the conclusions of each experiment are different. There is no in-depth study on the internal mechanism of the threshing process and the constitutive model of tobacco. This paper discusses the constitutive model of tobacco leaf, analyzes and studies the problem of tobacco leaf breakage in the process of threshing.

• From 1999 Belytschk and Moes proposed the term extended finite element method (XFEM)

main content and Methods

• the stress-strain curves of tobacco leaves and tobacco stems are obtained by doing specific mechanical characteristics tests of tobacco leaves and tobacco stems.

•With the help of XFEM method, the finite element model of tobacco leaves and tobacco stems is established in the simulation and the corresponding mechanical tests are carried out.

• The validity of the model is verified by comparing the stress-strain curves of simulation and actual experimen.

• In the process of studying the mechanical properties of tobacco leaves, the process of tensile fracture and shear fracture of tobacco leaves is involved. However, one of the commonly used methods to solve the fracture problem in the extended finite element method is to adapt to the mesh without re-meshing. The lattice geometry is discontinuous, so it is mainly used for discretization expansion. Therefore, this paper chooses the XFEM method for calculation and analysis.

The function used by the extended finite element method is the nodal extension function. In order to realize the fracture analysis, the extension function usually includes the crack tip asymptotic function and the discontinuous function. The displacement vector function using the overall division characteristic can be expressed as u as :

$$\mu = \sum_{i=1}^{N} N_i(x)[\mu_i + H(x)a_i + \sum_{\alpha=1}^{4} F_\alpha(x)b_i^\alpha] \qquad (1)$$

$N_i(x)$ Is the finite element node displacement shape function; u_i is the finite element displacement vector to solve the corresponding continuous part; a_i is the node expansion degree of freedom vector related to the crack surface; H (x) is the discontinuous jump function along the crack surface; b_i^α is the node related to the crack The extended degree of freedom vector; $F_\alpha(x)$ is the asymptotic function near the crack.

The model is meshed before the crack propagation. There are two forms of crack propagation: one is to expand along the element and the other is the collection of crack lines through a certain element, as shown in Figure 6. In formula (1), u_i it is applicable to all nodes in the model, H(x)a_i only the nodes whose shape function is passed through the element by the crack surface, and the nodes whose shape function is in the crack tip element.

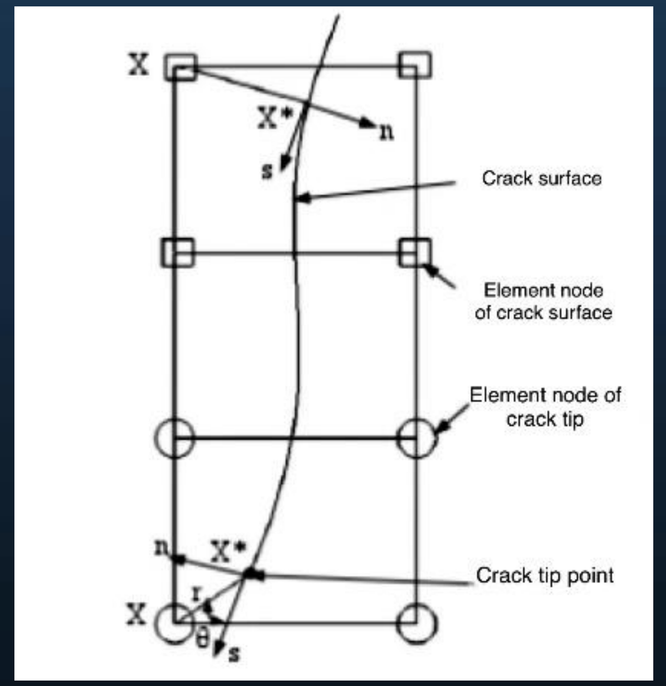


Figure 1. Schematic diagram of the crack surface passing through the element.

Simulation and analyze

•When material properties of the tobacco leaves are known, replace the tobacco leaves with a thin slice of the same size and thickness in the experimental part to conduct tensile fracture simulation. When crack growth analysis is performed by the finite element method, components need to be pre-cracked, Figure 2 The drawing and tearing process of the smoke sheet is obtained by post-simulation processing and the unit in the figure is Mpa.

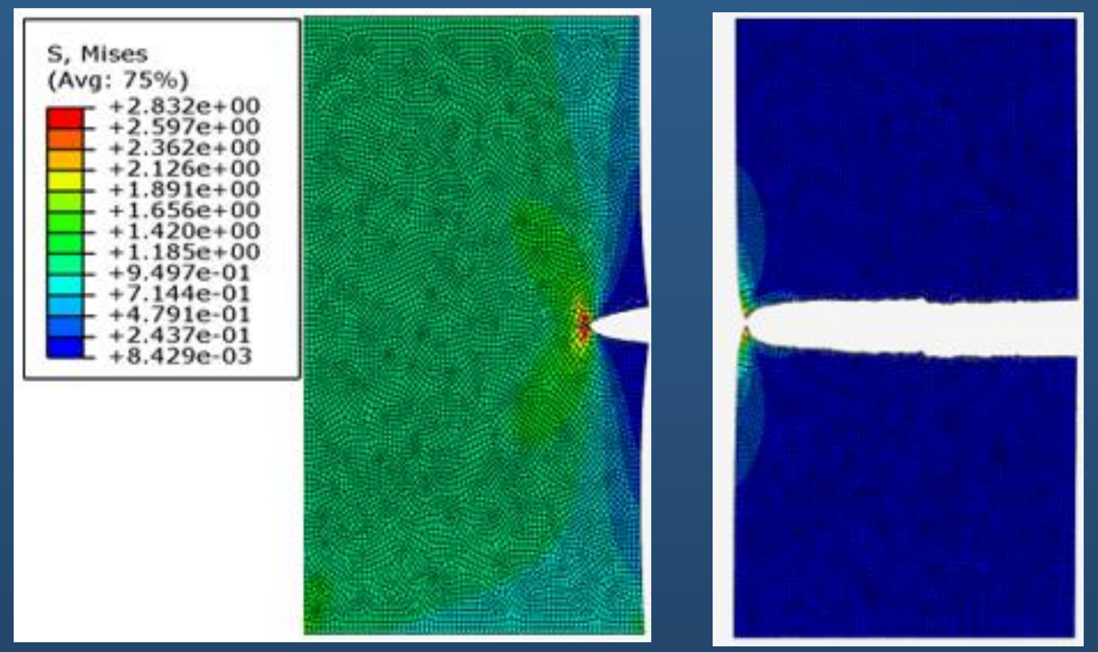


Figure2 . Tensile fracture process diagram of the tobacco leaves.

The force-time curve and stress-strain curve of an element above the crack of tobacco leaves are shown in Figure 3 and 4.

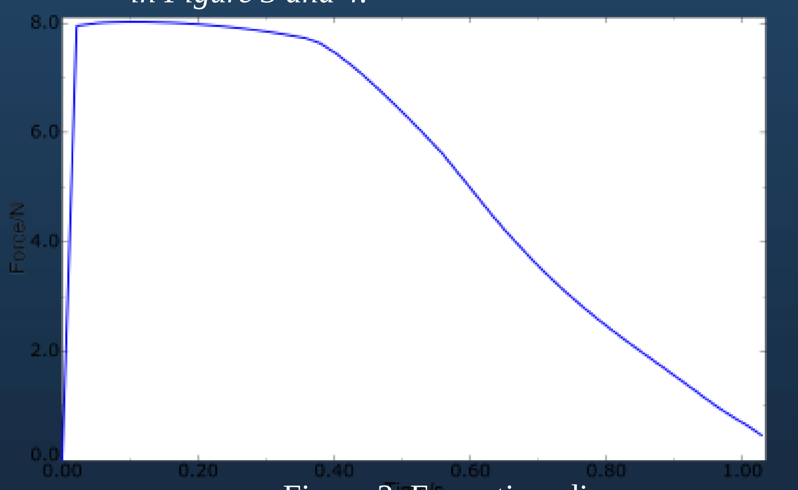


Figure 3. Force-time diagram.

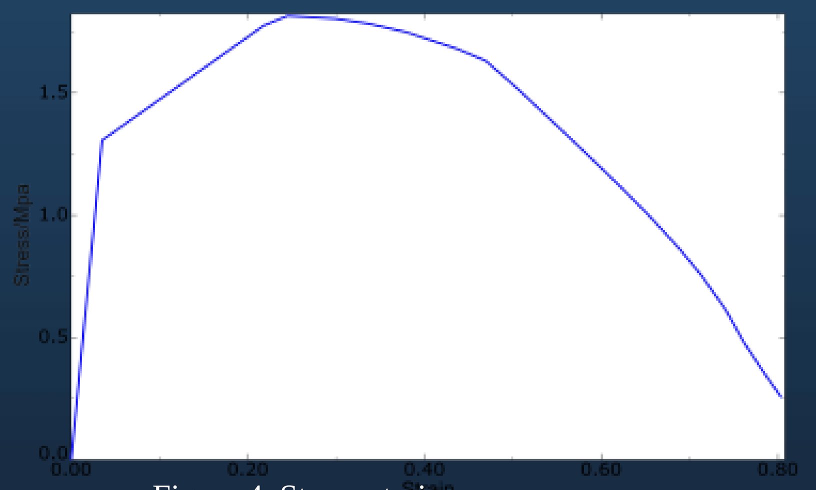
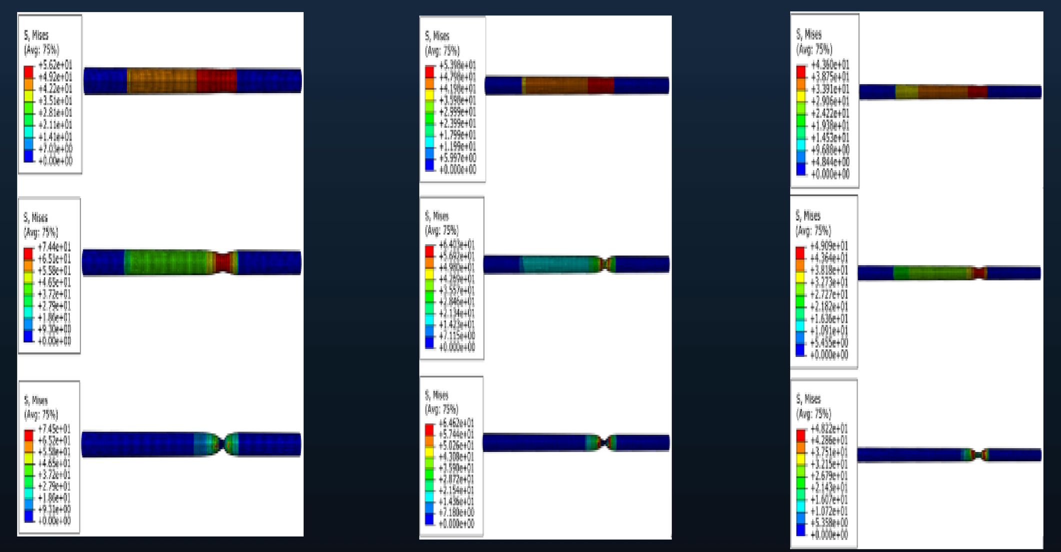
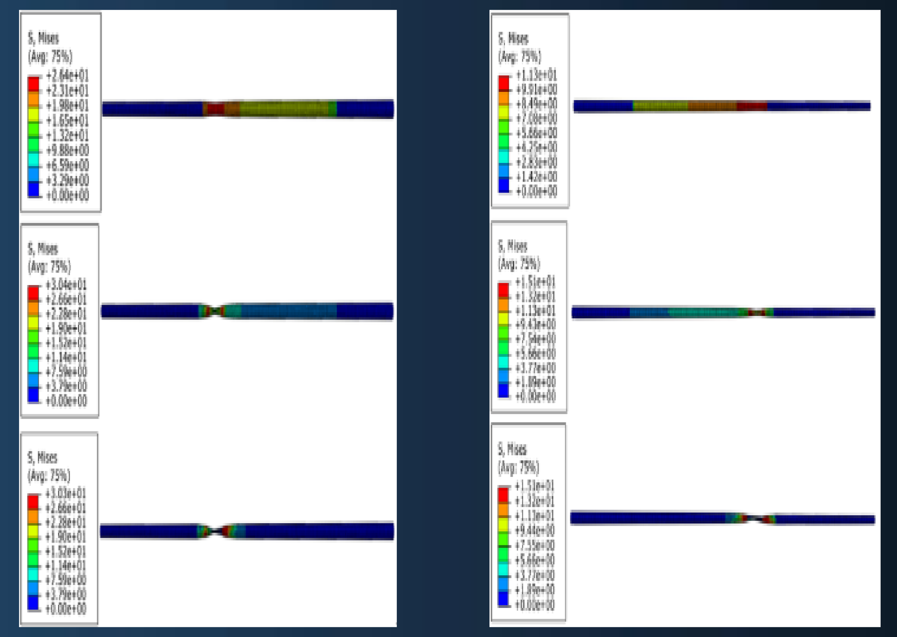


Figure 4. Stress-strain curve.



(a segment of tobacco stem) (b segment of tobacco stem) (c segment of tobacco stem）



(d segment of tobacco stem) (e segment of tobacco stem)

Figure 3. Tensile deformation diagram of tobacco stem.

Figure 3 shows the tensile deformation process of tobacco stem in sections A, B, C, D and E respectively. Because the diameters of both ends are different, the tensile deformation will occur at the thinner end, and the simulation deformation process is consistent with the fact. It can be seen from the figure that as the analysis steps increase or the time increases, the deformation of the tobacco stem becomes larger and larger, and the greater the deformation, the greater the tensile force.

Conclusion

•In the process of conducting I-mode fracture tensile simulation analysis on the whole tobacco leaf, as the tensile force increases, the length of the crack gradually increases. When the crack extends to the edge of the adjacent leaf vein, if it continues to expand in the direction of the crack, It needs more stretching force, more resistance, since the breaking force required to break the tobacco stem is much greater than the breaking force of the mesophyll, the crack will continue to propagate along the weaker side of the required breaking force, and obvious deflection will occur, so that the crack will move along the edge of the vein. Expand down. It is limitedly proved that the leaf veins have a good effect of retarding crack propagation. Or skip the tobacco stem to make the tobacco leaf on the other side crack.

•The trend of the stress-strain curve of tobacco stem fracture is basically similar to the stress-strain curve of experimental tobacco stem tensile fracture. Both have experienced the elastic stage, the plastic stage and the final damage stage, although the stress-strain curve above There are subtle differences between the elastic phase, the plastic phase, and the damage phase. In addition, the corresponding stress and strain values at the end of each phase are not the same. This is an inevitable error between the simulation results and the experimental results. The experimental results should prevail. However, the general curve trend and the experienced stage are basically unchanged, which indirectly verifies the simulation and experiment to each other, and initially completes the construction of the constitutive relationship of tobacco stem stretching