

Stress Analysis of Radial Compression Disk Based on MATLAB

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Abstract: Elastic mechanics is an important branch of solid mechanics, mainly studies the deformation and internal force of elastic objects under the action of external forces and other external factors, also known as elastic theory. The study object of elasticity is elastomer. The detailed theoretical structure helps us solve more practical engineering problems. We used Matlab software in the data simulation for visualization processing. On the basis of the study of elasticity, this paper explores the stress distribution of the uniform ideal elastic body to the radial compression disk model, and observes the change of the stress of the radial compression disk when the external pressure changes gradually. The expressions of the corresponding stress components σ_x , σ_y and τ_{xy} are obtained by using the theory of normal concentrated force on the boundary of a half plane body. The stress solutions considering the thickness t of the disk are derived. Finally, the drawing software in Matlab software is used to visualize the theoretical derivation results in order to intuitively feel the change of stress. After the data simulation, the data simulation results are compared with the stress analysis results derived from the theoretical deduction, and the conclusion is drawn.

Keywords: Elasticity, Stress analysis of radial compression disk, Visual processing.

1. Introduction

1.1. Research background and significance

In this paper, we mainly use the theory of elasticity. Elastic mechanics, an important branch of solid mechanics, studies the deformation and internal force of elastic objects under the action of external forces and other external factors, also known as elastic theory. It is the basis of material mechanics, structural mechanics, plastic mechanics and some interdisciplinary disciplines. The concept of elastic relationships was first proposed by British scientist Robert Hooke. Hooke's law was discovered in the 1660s, but when it was published, it was eight years later. Hooke's law established the concept of linear elasticity, but it has not yet been expressed in the form of stress and strain. Then the Bernoulli brothers introduced the concept of stress and strain. In 1829, the French scientist Poisson considered the problem of lateral contraction in unidirectional stretching. In honor of his contribution, the negative value of the ratio of lateral contraction to longitudinal elongation was named Poisson's ratio. In addition, Poisson also discovered shear and longitudinal waves, pioneering elastodynamic analysis.

In the second half of the 20th century, various branches of elasticity have developed vigorously, and elasticity is now widely used in industrial production and other aspects, because we in the mechanics of materials and theoretical mechanics and other disciplines, there are some assumptions, which will abstract and simplify our real life mechanical problems into a mechanical model. For example, the rigid body hypothesis in theoretical mechanics, the flat section hypothesis in material mechanics, based on these assumptions to create an idealized model, so as to obtain approximate solutions to mechanical problems. Elastoplastic mechanics, on the other hand, starts with the stress state and strain state of the unit body at a point in the solid under various stress conditions, and establishes the basic equations and theories that are generally applicable through analysis, and considers different boundary conditions to meet specific problems, and

then obtains a more accurate solution reflecting the strain and stress distribution law of the solid through data simulation and calculation.

On the other hand, some engineering problems we encounter in real life can not be simplified into a mechanical model, so in this case, the theoretical methods of material mechanics and theoretical mechanics can not be solved, can not effectively use resources, improve economic benefits. However, in elastic mechanics, the above problems can be solved, we use Matlab numerical simulation software, which has its unique advantages in simulation experiments, such as simple operation, easy to master, a variety of drawing methods, beautiful map, can be post-processed map, and so on, and the simulation speed is fast, good repeatability, conducive to the learning and research of concepts. Not only with its wide application, but also with its convenience and visibility, but also because it is currently in the preliminary exploration stage in the field of mechanics, it is waiting for more people to join in the research, jointly brainstorm, expand its application, and make it play a better role in scientific research.

1.2. Research status at home and abroad

Xu Pei'an[1] obtained the experimental solution of the disk under radial pressure by using the method of electric simulation experiment, which is basically consistent with the theoretical solution of the disk. The method of electric simulation experiment is to solve the principal stress sum of the disk under radial pressure by experiment, and the most convenient way to simulate the physical phenomenon of the principal stress sum is to use the potential in the stable electric field. In the past, electrolyte was used to make the electric field, but its disadvantage is that the model is complicated and the electric field is destroyed during measurement. In this paper, the shortcomings of liquid electric field are overcome by the method of semiconductor paper electric simulation experiment. In particular, it avoids the complicated process of numerical integration of the Laplace equation.

Based on the anisotropy analysis of Okubo, Xu Luwen[2] studied the radial compression disk made of fiber reinforced photoelastic composite materials, and on this basis proposed a method to determine the three fringe values of the photoelastic composite materials by using a radial compression disk. Compared with the corresponding material fringe values measured by three straight strips of photoelastic composite, it is found that the present method is more simple and reliable. The results obtained by this method depend largely on the preparation of the sample and the test method, and are often relatively dispersed. When the diametral compression disk is used to measure the fringe value of the material, the measured position is the center of the specimen, the boundary effect is less, and the state of two-way stress is more universal than the unidirectional stress. In fact, Okubo has obtained the stress distribution of the disk under radial pressure due to anisotropy by means of the complex function. Based on Okubo's anisotropy analysis, the author attempts to obtain the stress of the center point of the disk under radial pressure.

Zhang Wu[3] made a new attempt to study the radial stress distribution of microtransparent actual fiber composites on radial compression disks by using a micro laser analyzer. The radial stress distribution of the disk under radial compression can be obtained by means of graph method, and the results are in agreement with Okubo's theoretical calculation. The experiment shows that the actual fiber composites with light transmittance as low as 6 parts per 10,000 can be tested by using the above method. The stress distribution of fiber reinforced composites is very important for engineering design. However, there is still a lack of powerful means to determine the internal stress distribution of these materials. Moire method, holographic method and other optical measurement techniques mainly reflect the internal situation of the material through the change of the surface strain field. The test result is related to the distance from the stress concentration point to the surface, so it has great uncertainty. The transmission photoelastic method requires high transparency and optical uniformity of the tested sample. Therefore, it can not be directly used for stress analysis of actual fiber reinforced composite materials. The research method of transparent photoelastic composites developed in the early 1970s is only a simulation study. The problem from model to prototype has not been really solved, and the simulated results may be quite different from the actual internal stress distribution of fiber composites. Therefore, it is necessary to explore new research methods suitable for the internal stress analysis of actual fiber composites.

The application of radial compression disks in life is known as the Brazilian splitting experiment, and the research results in this area are also quite fruitful:

Yu Junhong[4] believes that disc fracturing is an indirect test method to measure the tensile strength and elastic modulus of rocks, and its theoretical basis is the elastic theoretical solution of the stress and displacement of the compressed disc. The theoretical analysis of the compression disc is carried out by using the method of complex variable function. The analytical solutions of the stress and displacement on the compression diameter of the disc are given, and the theoretical formulas for solving the tensile strength and elastic modulus are also given. For typical brittle materials, such as rocks, it is difficult to determine the tensile strength by direct tensile test, and the Brazilian splitting test is generally used to determine the tensile strength of shale

indirectly. It is concluded that there is little difference in the distribution of shear stress on the vertical lines corresponding to the two kinds of contact loads within a certain range. The closer you get to the edge of the disc, the greater the difference, and the smaller the contact Angle, the greater the effect.

Yu Yong[5] pointed out that the current tensile strength formula of rock Brazilian disk test used for more than 40 years is derived from the solution of two-dimensional elastic mechanics, which is not applicable to the three-dimensional elastic mechanics problem corresponding to the actual situation. In order to obtain the stress distribution law inside the sample under three-dimensional condition, the elastic force analysis of the sample was carried out by using the three-dimensional finite element analysis software Marc. The results showed that the distribution law of tensile stress on the cross-section of the sample was similar to that under two-dimensional condition, but the stress value on the cross-section varied along the thickness direction of the sample. The closer the two ends were, the greater the horizontal tensile stress was. It is found that the tensile strength calculated by the two-dimensional formula is 23.3% lower than the real value for the Brazilian disc sample with height-diameter ratio of 1 and Poisson ratio of 0.25.

You Mingqing[6] introduced the platform as the loading surface in the Brazilian disk sample, which can improve the stress state at the loading place. When using finite element method to calculate the uniform displacement and compression of the Brazilian disc of the platform, with the increase of the center Angle of the platform, the tensile stress of the center of the disc decreases and the ratio of compressive to tensile stress increases. Therefore, it is necessary to study whether the application of Griffith criterion can determine the tensile strength of the rock and how to select the center Angle of the platform. For granite, sandstone, limestone and diabase, the disk is not broken along the center line, and the tensile strength increases with the increase of the center Angle of the platform. There are two reasons, one is that the Griffith criterion overestimates the tensile strength, and the other is that there is friction between the indenter and the platform. The disc of the platform can be broken along the center line by inserting 0.5 mm thick PTFE sheet, but the lateral deformation of the gasket is larger than that of the rock, and the platform is subjected to the friction force pointing outward, which makes the strength of the disc decrease with the increase of the center Angle.

1.3. Main content of this paper

This paper mainly carries out the following three aspects of work:

(1) The basic theory of elasticity is used to make a theoretical analysis of the radial compression disc, so as to obtain the analytical solution of the stress of the radial compression disc;

(2) Using Matlab software to numerically simulate the stress problem of the opposite-diameter compression disc, the corresponding σ_x , σ_y and τ_{xy} under different pressures of the opposite-diameter compression disc are obtained, and the maximum shear stress τ_{max} and the main direction θ are obtained, so as to obtain an intuitive visual effect;

(3) According to the theoretical analysis results and the images obtained by Matlab software, comparative analysis.

2. Stress Analysis of Radial Compression Disk

2.1. Brief introduction to the radial compression disc model

Diametrically compressed disk is one of the classical mechanics problems in the course of elasticity. Suppose that an ideal elastic-plastic disk with diameter d is subject to opposite and equal concentrated forces F in the radial direction of AB, we call it the contrary-diameter compression disk model.

2.2. Theoretical analysis of compression disc

The paper deduces the stress theory of the disk under radial compression and starts with the study of the half plane subject to the normal concentrated force on the boundary in elasticity. Now, we make the center Angle of the wedge equal to a flat Angle, so that the two sides of the wedge form a straight edge, and the wedge becomes a so-called half plane, as shown in Figure1. Therefore,

When the plane is subjected to a force F perpendicular to the boundary, the stress component can be calculated.

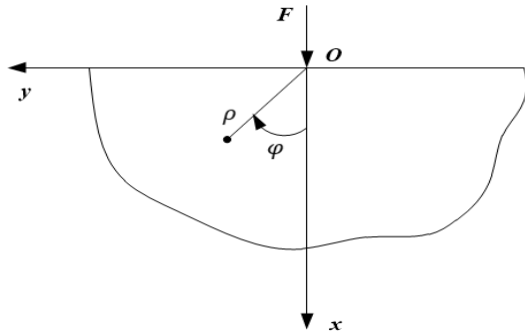


Figure 1. Half plane subject to concentrated force

Let $F = p$, then the stress component in the cartesian coordinates can be obtained:

$$\begin{cases} \sigma_x = -\frac{2p \cos^3 \varphi}{\pi \rho} \\ \sigma_y = -\frac{2p \sin^2 \varphi \cos \varphi}{\pi \rho} \\ \tau_{xy} = -\frac{2p \sin \varphi \cos^2 \varphi}{\pi \rho} \end{cases} \quad (1)$$

Converting the polar coordinates into cartesian coordinates, we get:

$$\begin{cases} \sigma_x = -\frac{2p}{\pi} \frac{x^3}{(x^2 + y^2)^2} \\ \sigma_y = -\frac{2p}{\pi} \frac{xy^2}{(x^2 + y^2)^2} \\ \tau_{xy} = -\frac{2p}{\pi} \frac{x^2 y}{(x^2 + y^2)^2} \end{cases} \quad (2)$$

Now, we consider that there is a disk with a diameter of d , and at both ends of a diameter AB, a pair of concentrated forces F of the same size and opposite direction are acted on. The structure of the specimen is shown in Figure 2, and the stress solution is analyzed and given.

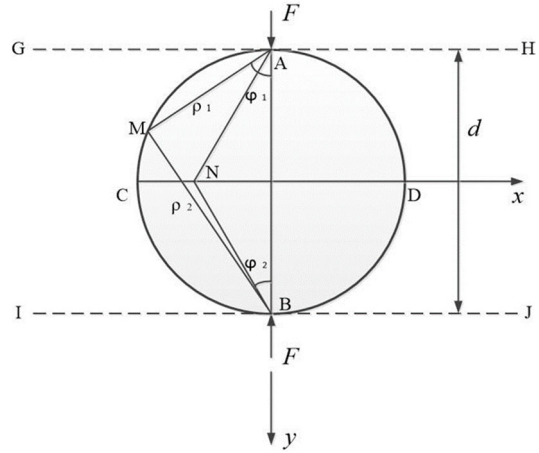


Figure 2. Disk subjected to radial concentrated force

Here, we can apply the solution of the half plane subject to the vertical concentration force, and then superimpose the result. Assuming GH is A semi-plane below, under the action of F at point A, we can get:

$$\sigma_{\rho_1} = -\frac{2F \cos \varphi_1}{\pi \rho_1} \quad (3)$$

$$\sigma_{\varphi_1} = \tau_{\rho\varphi_1} = 0 \quad (4)$$

Assuming that IJ is a semi-plane, under the action of F at point B, it can be similar to:

$$\sigma_{\rho_2} = -\frac{2F \cos \varphi_2}{\pi \rho_2} \quad (5)$$

$$\sigma_{\varphi_2} = \tau_{\rho\varphi_2} = 0 \quad (6)$$

That is, at point M of the circumference, there are two stresses σ_{ρ_1} and σ_{ρ_2} , and since AM is perpendicular to BM, there are:

$$\frac{\cos \varphi_1}{\rho_1} = \frac{\cos \varphi_2}{\rho_2} = \frac{1}{d} \quad (7)$$

So, on the circumference, there is:

$$\sigma_{\rho_1} = \sigma_{\rho_2} = -\frac{2F}{\pi d} \quad (8)$$

The two are synthesized into the normal distribution pressure on the circumference. In order to eliminate the distribution pressure on the circumference, the distribution tension $\frac{2F}{\pi d}$ should be applied on the circumference, and the corresponding stress component is:

$$\sigma_{\rho} = \sigma_{\varphi} = \frac{2F}{\pi d} \quad (9)$$

$$\tau_{\rho\varphi} = 0 \quad (10)$$

The stress component on the horizontal line CD can be obtained as:

$$\sigma_y = \frac{2F}{\pi d} \left[1 - \frac{4d^4}{(d^2 + 4x^2)^2} \right] \quad (11)$$

The maximum compressive stress occurs at the center of the disc

$$(\sigma_y)_{x=0} = -\frac{6F}{\pi d} \quad (12)$$

Now, on the basis of the above theory, and then consider the thickness of the radial compression disk, to solve the stress solution under this condition. Suppose that a homogeneous disk with radius r and thickness t is subjected to a pair of equally large reverse concentrated forces P in the vertical direction, as shown in Figure 3.

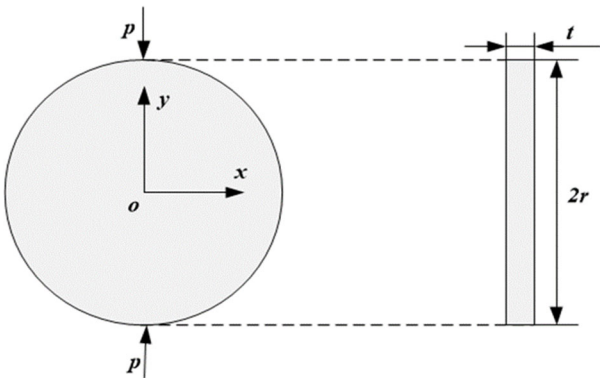


Figure 3. Dimensions of the compression disc specimen

According to the stress solution obtained by the concentrated force on the above half plane, after considering the thickness of the radial compression disk, the stress solution of the disk surface can be obtained as follows:

$$\begin{cases} \sigma_x = \frac{2p}{\pi t} \left\{ \frac{(r+y)x^2}{[(r+y)^2 + x^2]^2} + \frac{(r-y)x^2}{[(r-y)^2 + x^2]^2} - \frac{1}{2r} \right\} \\ \sigma_y = \frac{2p}{\pi t} \left\{ \frac{(r+y)^3}{[(r+y)^2 + x^2]^2} + \frac{(r-y)^3}{[(r-y)^2 + x^2]^2} - \frac{1}{2r} \right\} \\ \tau_{xy} = \frac{2p}{\pi t} \left\{ \frac{(r+y)^2 x}{[(r+y)^2 + x^2]^2} - \frac{(r-y)^2 x}{[(r-y)^2 + x^2]^2} \right\} \end{cases} \quad (13)$$

3. The Application of Matlab in Mechanics

3.1. Matlab Software Introduction

Matlab is a software system developed, maintained and operated by Mathworks. Matlab is very powerful. As we all

know, Matlab is a programming language. Therefore, it can be used for program development as well as C language, Fortran and other programming languages. Matlab is also a powerful tool for numerical calculation. In fact, it was developed for the purpose of numerical calculation, its internal integration of a large number of numerical calculation functions. Matlab also includes a powerful library of data visualization functions that make it easy to plot and visualize data. The most important thing is that Matlab integrates a lot of special toolbox, each toolbox is a function library for special problems, with these functions can achieve a lot of functions, convenient for us to flexibly use in practical problems. For example, the image processing toolbox of Matlab contains the functions of digital image processing and almost all common functions in the application, which can easily achieve complex image processing.

Matlab has many functions, such as data visualization, numerical calculation, partial differential equation solving, data collection and processing, and other functions can be directly used for theoretical analysis of mechanical problems, numerical calculation, and experimental signal collection, processing and analysis. Of course, in order to achieve flexible use of these functions, we must first master the basic knowledge and use skills of Matlab.

In recent years, Matlab has been favored by the majority of users for its advantages of easy operation and strong visualization. In addition, the basic data unit of Matlab is a matrix, and its instruction expression is very similar to the form commonly used in mathematics and engineering, so it is widely used in engineering disciplines. At the same time, through its full graphical capabilities for engineering and scientific data visualization, it is increasingly becoming the most widely used language in the engineering community today.

The characteristics and system of Matlab also determine the disadvantages of Matlab. Matlab is not very good at the following. The first is the standalone application. Matlab is an interpreted language, that is, Matlab programs must be run in the Matlab environment. In other words, if you want to run a Matlab program on a machine, then the machine needs to install Matlab system. This is different from compiled languages. For example, if you write a program in C, you can compile it into an executable file and run it on any machine, whether or not the C compiler is installed on that machine. This kind of application that can be separated from the programming language environment is called a "Stand alone application". Matlab is not good at "standing alone application". Therefore, if you want to make a software product for sale, Matlab is definitely not a good choice.

In addition, Matlab is not good at developing large applications. The "convenience" of Matlab just buried the "curse" of its language is not strict, so the development of large applications with Matlab will encounter many problems. All in all, Matlab was simply not designed for the development of large applications. Nowadays, there are fewer and fewer things that Matlab can't do. The new version of Matlab has been added to the toolbox, which can complete some new tasks. It's like adding new functionality. In addition, Matlab is an open system, as long as the user is willing to work hard, many things can be achieved. Therefore, there are opportunities in the future, but also need a deeper level of study and research, in order to find a broader world.

3.2. PDE TOOLBOX Describes the functions of the toolbox

MATLAB-PDE toolbox is a set of tools used to study and solve partial differential equations, which provides a comfortable and flexible working environment for the study and solution of partial differential equations in two-dimensional space.

The main features of the PDE Toolbox include:

Research and solve one - and two-dimensional partial differential equation problems, and provide a comfortable and flexible user interface, which can be interactive to achieve the establishment of partial differential equation geometric model, boundary condition determination, triangular mesh division and encryption, partial differential equation types and parameter Settings, equation solving and display results of the graph. It includes a complete set of programs such as pre-processing, calculation and post-processing of numerical solution. The numerical solution of partial differential equations can be realized intuitively, quickly and visually.

In general, it is difficult to obtain the analytical solution of the partial differential equation when solving problems, but Matlab actually uses the finite element method to obtain the numerical solution of the partial differential equation, and obtains the accurate solution infinitely close by encrypting the grid. This is also convenient for our scientific research.

PDE toolbox can only be solved in two-dimensional space, but combined with the symmetry of most mechanical problems, the model can be transformed, and we can choose a representative cross-section for analysis. For example, the analysis of cylinder and ring structure. Because of its symmetry, cross-section method can be used to build a model based on its cross-section, and then perform data simulation analysis.

MATLAB-PDE toolbox, for the general partial differential equations can be solved, so it is a more practical numerical calculation tool, especially when the boundary conditions are relatively simple, the user almost does not have to learn programming, only in the graphical user interface window for simple operations, you can get the graph solution of the equation. This is an invaluable tool for many students who need to solve partial differential equations and are not very good at programming. It's worth learning from.

3.3. Matlab application Examples

Given here is a classical problem in the mechanics of materials, is a relatively simple problem, the cantilever beam at the end of the concentrated load. The derivation process and the result of using Matlab drawing software are given below.

Deformation calculation of cantilever beam subjected to concentrated load at the end:

Assume that $F = 20KN$ cantilever beam is subjected to concentrated force A at the end, and the cross-section size of the beam is $b = 300mm$, $h = 600mm$, as shown in Figure 4. The span of the beam is $l = 5m$ and the elastic modulus is $E = 210Gpa$. Try to solve the Angle and deflection of the beam and draw the deformation curve.

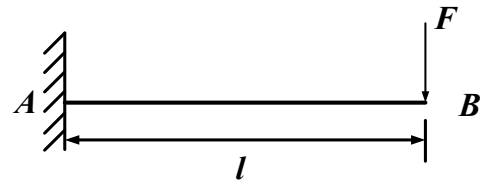


Figure 4. Deformation calculation diagram of cantilever beam

According to the meaning of the question, the bending moment equation can be listed as:

$$M(x) = -F(l - x)$$

Approximate differential equation from the flexure line:

$$EI\omega'' = -M(x) = Fl - Fx$$

By scoring twice, the first score is:

$$EI\omega' = Flx - \frac{Fx^2}{2} + C_1$$

Once again, the score is:

$$EI\omega = \frac{Flx^2}{2} - \frac{Fx^3}{6} + C_1x + C_2$$

From the boundary conditions of the cantilever beam, the integral constant is:

$$x = 0, \quad \omega = 0 \quad \therefore C_2 = 0$$

$$x = 0, \quad \omega' = 0 \quad \therefore C_1 = 0$$

By substituting the determined integral constant into the equations of Angle and flexure, we can get:

$$\theta = \omega' = \frac{Flx}{EI} - \frac{Fx^2}{2EI}$$

$$\omega = \frac{Flx^2}{2EI} - \frac{Fx^3}{6EI}$$

$$\omega_{\max} = \frac{Fl^3}{3EI}$$

The result is:

$$\theta_{\max} = 2.205 * 10^{-4} \text{ rad}$$

$$\omega_{\max} = 7.349 * 10^{-4} \text{ m}$$

According to the obtained results, the deflection is positive, indicating that section B is moving downward. A positive Angle indicates that section B rotates clockwise.

Run the program and get the result, as shown in Figure 5:

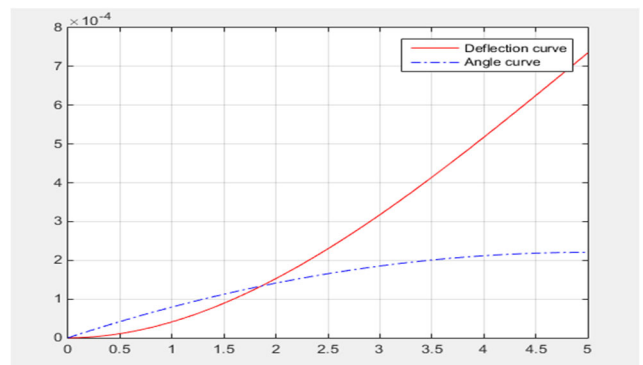


Figure 5. Deformation curves of Angle and deflection

From the examples analyzed above, we can see that the introduction of Matlab programming function in the mechanics course not only has great help in the calculation of internal force and deformation of the bar or bar structure, but more importantly, it will have a positive effect on the teaching of the course and the cultivation of students' learning and innovation ability. We can relieve the pressure of calculation by using Matlab software. Better understand, use the principles of mechanics. In the process of using software, we also develop our computer skills and the ability to combine engineering and theory. Innovation capacity has also improved significantly. It provides us with a good platform for independent study and research study.

Matlab also has applications in elasticity. The basic equations of plane problems in elasticity are two-dimensional. When the boundary conditions are determined, displacement method or stress method can be used to solve the partial differential equations of plane problems. In the plane problem of elasticity, PDE provides three boundary conditions, Dirichlet, Neumann and Mixed, which correspond to stress boundary conditions, displacement boundary conditions and mixed boundary conditions. The PDE toolbox in Matlab software provides great convenience for the solution of the plane problem in elasticity. It can provide visual color graphics for the solution results, which brings great convenience to the teaching of elasticity. PDE toolbox uses elliptic partial differential equations to solve plane problems in elasticity, which is the displacement numerical solution of elasticity.

The analytical solutions to problems in elasticity are generally very long and complex formulas, and it is impossible for most of us students to visualize the results of these formulas in our minds and quickly understand their meaning. If these formulas are visualized into intuitive graphs or images, the meaning is easy to understand. Therefore, the visualization of complex formulas will be very helpful to the understanding of the analytical solutions of elasticity. We will complete the Matlab data simulation of the radial compression disk in the next chapter.

4. Numerical Simulation of Diametrically Compressed Disks

Consider a pair of diameter compression disks, radius $r = 25$ mm, thickness $t = 5$ mm, using the relevant knowledge of elasticity and Matlab software functions to visualize when the pressure P is 1N, 10N, 1000N respectively. σ_x , σ_y and τ_{xy} of compression disks and related research data.

4.1. Data matrix generation and detail processing

First set the calculation area and give the coordinates of each point on the disk. This step can be achieved using Matlab's meshgrid function. Generate the computed region lattice. When drawing, we also need to consider a lot of details, for example, we have a problem with the stress solution of the disk, that is, the region outside the disk also has stress values. To eliminate the effects of these regions, determine the range of the disk first, and then set the data point for the region outside the disk to 0.

After the stress component data matrix is generated, it can be visualized by Matlab drawing function. When we use

contourf to display σ_x , we can see that even though the region outside the disk is set to 0, these Settings cause "trouble" for the drawing function. At the boundary of the specimen, it is difficult to display the data in the formal drawing area because of the stress jump. At this time, we can use the nan of MATLAB to perfectly solve the above problems. nan has two characteristics, that is, the result of any operation is nan: the drawing function does not process the nan data point, and displays the background color at the data point.

Take σ_x as an example, as shown in Figure 6:

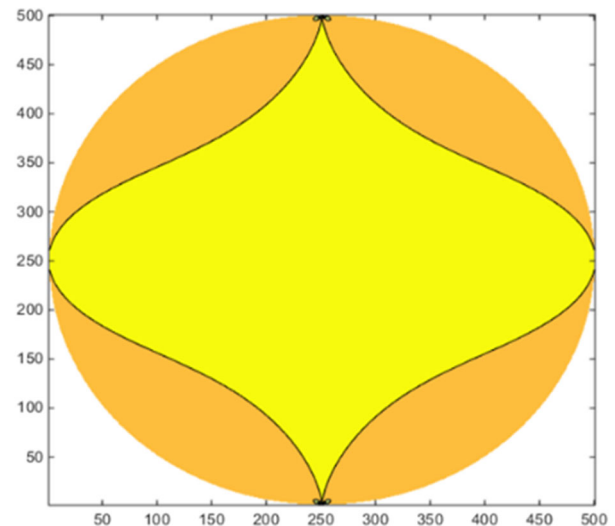


Figure 6. Data simulation effect

4.2. The visualized results are obtained under three stress conditions

Using pcolor function in Matlab software, the x - direction stress, y - direction stress and shear stress of contra - diameter compression disk are visualized.

When the pressure P is 1N, the visualization result of σ_x is shown in Figure 7; the visualization result of σ_y is shown in Figure 8; the visualization result of τ_{xy} is shown in Figure 9.

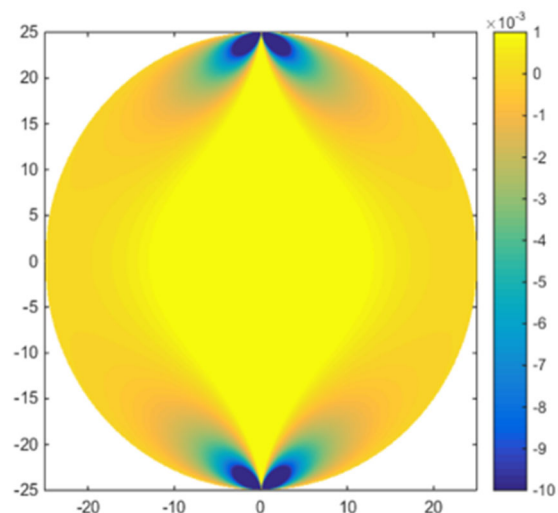


Figure 7. $\sigma_x (p = 1N)$

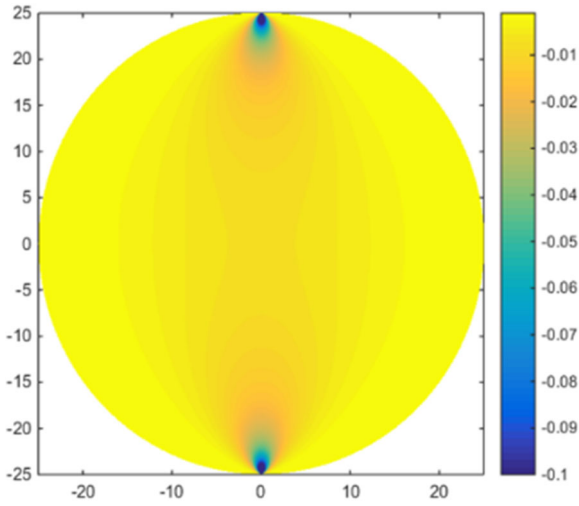


Figure 8. $\sigma_y (p = 1 \text{ N})$

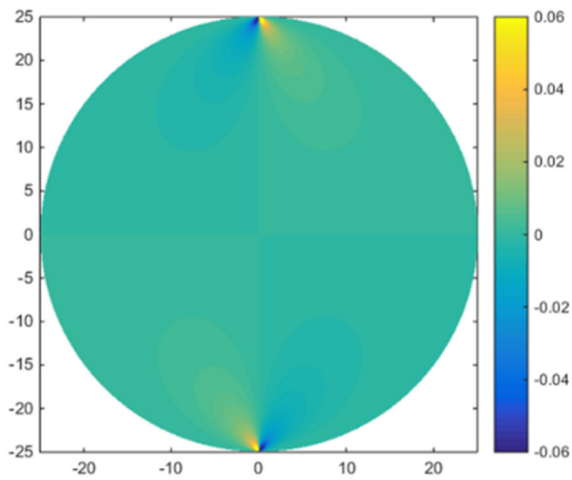


Figure 9. $\tau_{xy} (p = 1 \text{ N})$

In addition, we can also calculate the maximum shear stress τ_{\max} and the principal direction θ of the disk under radial compression through the obtained σ_x, σ_y and τ_{xy} . In the field of experimental mechanics, there is a method to measure the distribution of stress field called photoelastic method, whose isometric line and isocline exactly represent the principal stress difference and principal direction, and its fringe distribution is similar to the distribution of these two fields.

When the pressure P is 1N, the visualization result of the maximum shear stress τ_{\max} is shown in Figure 10; the visualization result in the main direction θ is shown in Figure 11;

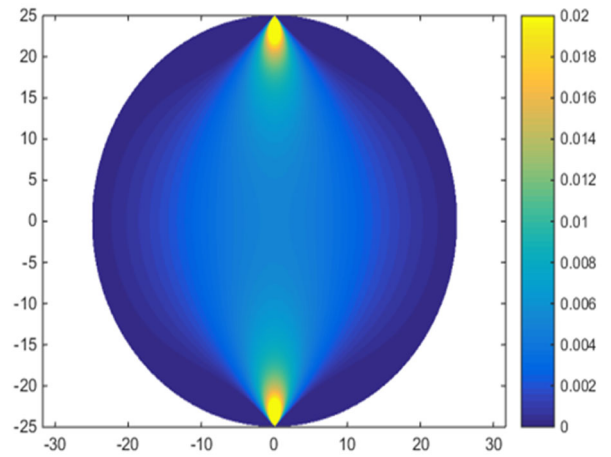


Figure 10. $\tau_{\max} (p = 1 \text{ N})$

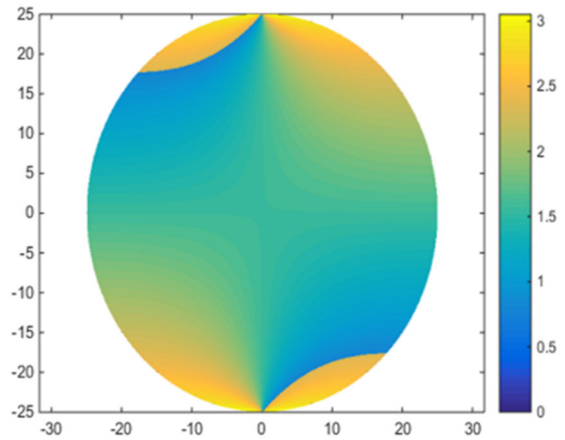


Figure 11. $\theta (p = 1 \text{ N})$

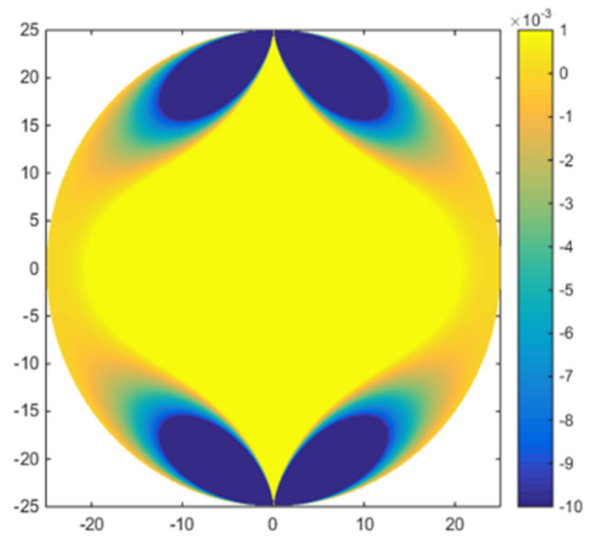


Figure 12. $\sigma_x (p = 10 \text{ N})$

When the pressure P is 10N, the visualization result of σ_x is shown in Figure 12; the visualization result of σ_y is shown in Figure 13; the visualization result of τ_{xy} is shown in Figure 14; the visualization result of the maximum shear stress τ_{\max} is shown in Figure 15.

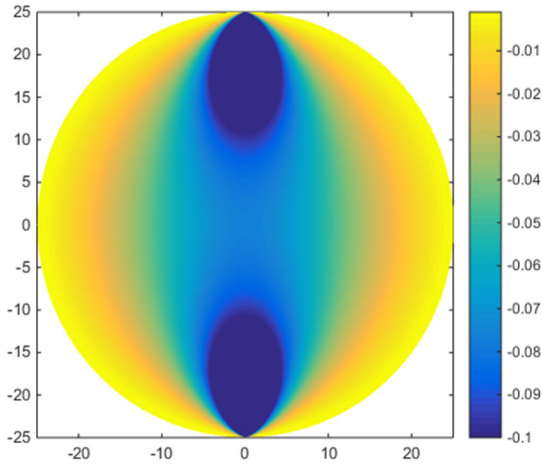


Figure 13. σ_y ($p = 10$ N)

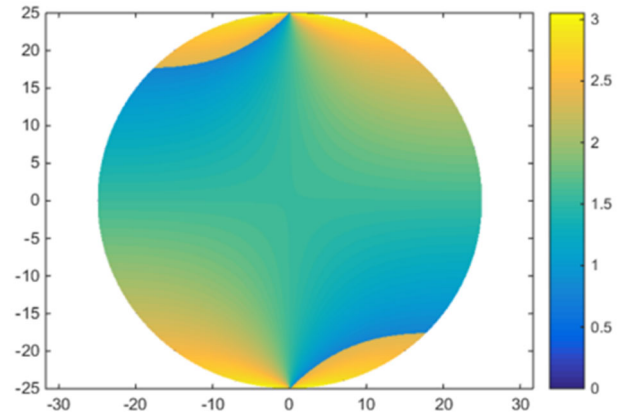


Figure 16. Main direction θ Visualization result ($p = 10$ N)

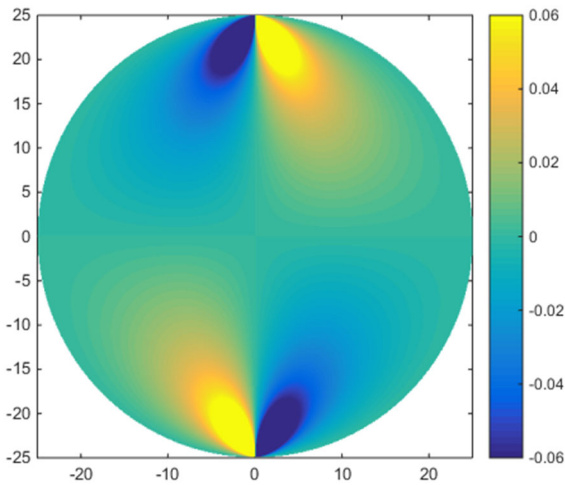


Figure 14. τ_{xy} ($p = 10$ N)

When the pressure P is 1000N, the visualization result of σ_x is shown in Figure 17; the visualization result of σ_y is shown in Figure 18; the visualization result of τ_{xy} is shown in Figure 19; the visualization result of the maximum shear stress τ_{max} is shown in Figure 20; the visualization result in the main direction θ is shown in Figure 21.

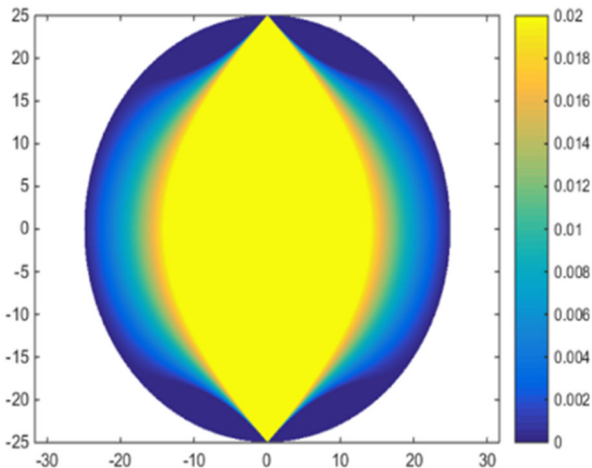


Figure 15. τ_{max} ($p = 10$ N)

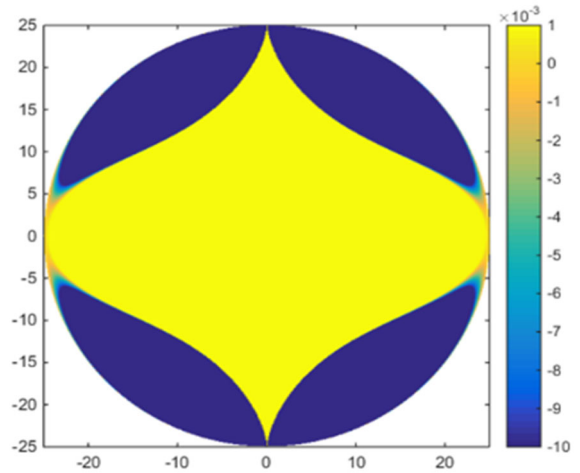


Figure 17. σ_x ($p = 1000$ N)

When the pressure P is 10N, the visualization result in the main direction θ is shown in Figure 16:

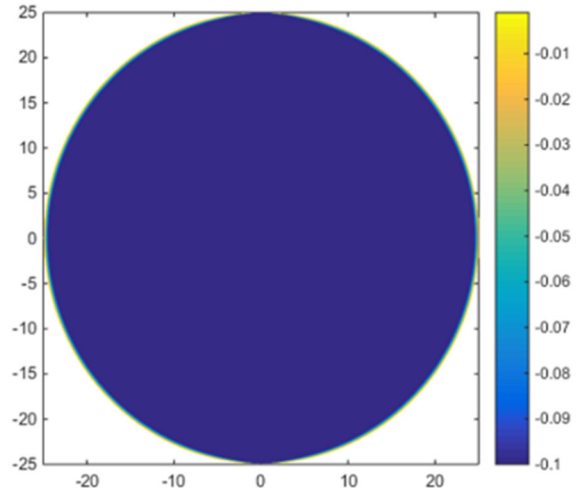


Figure 18. σ_y ($p = 1000$ N)

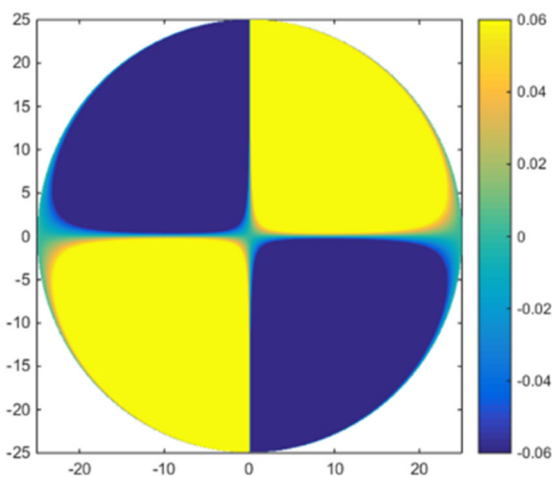


Figure 19. τ_{xy} ($p = 1000$ N)

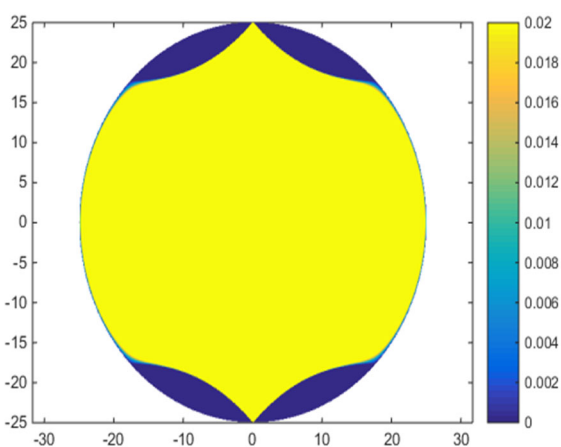


Figure 20. τ_{max} ($p = 1000$ N)

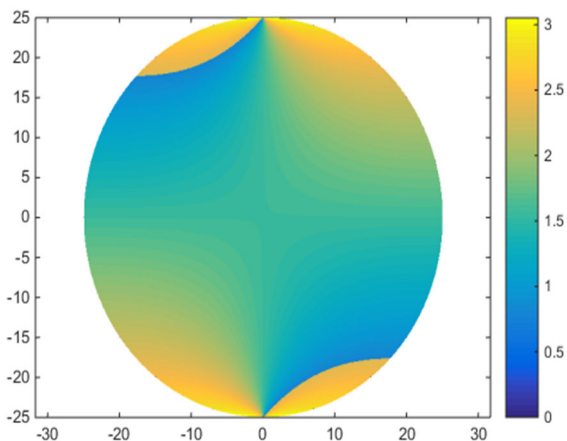


Figure 21. θ ($p = 1000$ N)

4.3. Analysis and comparison of visual results

When trying to test with different pressure values, the corresponding σ_x , σ_y and τ_{xy} of the pressure disk changed with the gradual increase of the pressure value, and their respective maximum values increased with the gradual expansion of the regional distribution in the diametral pressure disk, but the main direction did not change accordingly; Under the same pressure value condition, the corresponding σ_x of the pressure disk has a maximum value

in the middle of the disk, σ_y has a stress value distribution at the place where the pressure is applied, and τ_{xy} is symmetrically distributed at the center of the disk on both sides of the pressure direction.

5. Conclusion and Prospect

5.1. Conclusion

In this paper, based on the knowledge of elasticity and the reference of relevant literature, the stress analysis of the contrary-diameter compression disc model under three different pressure values is made. σ_x , σ_y and τ_{xy} of the disk are derived by theoretical analysis. Finally, the visualization process is carried out by using the drawing software in Matlab. The visualization results of the maximum shear stress τ_{max} and the principal direction θ are also obtained. The results are compared with the theoretical results and three stress conditions, and the color visualization effect of the numerical stress solution is realized. Through theoretical analysis and numerical simulation, the following conclusions are obtained:

Through the theory of elastic mechanics, the stress solution of the counteraxial compression disk under three different pressure conditions can be derived. According to the analysis, under the three stress conditions, the range of stress σ_x , σ_y and τ_{xy} will expand with the increase of pressure value, but the shape of the distribution range will not change. Moreover, the principal direction θ does not change accordingly, indicating that increasing the pressure value will only increase the corresponding stress value, but will not change the principal direction.

5.2. Prospect

As the pressure P increases. σ_x , σ_y and τ_{xy} in the pressure disk are all increasing. The specimen is an ideal elastoplastic material. Therefore, when the combination of stress components reaches a certain critical value, the material will enter a plastic deformation state and gradually form a plastic zone. We can imagine that as the pressure continues to increase, the plastic zone continues to expand, and the elastic zone continues to decrease, until the pressure disc all enter the plastic state. For ideal elastic-plastic materials, when all enter the plastic state, it can be interpreted as the plastic limit state of the disk. When the disk reaches the plastic limit state, that is, if the load continues to increase, damage will occur.

References

- [1] Xu Pei 'an. Calculation of Opposity-diameter compression Disk by Electric Simulation Test [J]. Journal of Changsha University,2001.12:15-17
- [2] Xu Luwen. Stress Analysis of Photoelastic composite on radial compression Disk and Measurement of material fringe Value [J]. Journal of Nanjing University of Aeronautics and Astronautics,1986.12:119-126
- [3] Zhang Wu, et al. Study on Stress distribution and optical Relationship of optically inhomogeneous fiber composite to diameter compression disk [J]. Journal of Composite Materials,1995.9:90-95

- [4] Yu Junhong, et al. Elastic Theory Analysis of Compression Disc [C]. The 16th Academic Conference of Urban Mechanics Society of Seven Northern Provinces, Hohhot, Inner Mongolia, China,2016-08-06:19-22
- [5] Yu Yong, et al. Spatial tensile stress distribution in Brazilian disk test [J], Rock and Soil Mechanics,2005,12:48-51
- [6] You Mingqing, et al. Experimental study on rock splitting and rock tensile strength of Brazilian platform [J], Chinese Journal of Rock Mechanics and Engineering,2004,18:72-78