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Research Article

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Finite element analysis of interference fit between the car swing arm and shaft sleeve

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ABSTRACT

Analyze the problem of automotive arm and sleeve assembly interference by using the finite element simulation. The results show: without considering the impact on the taper to the contact, the contact surface pressure and axial pressure generated at the outer sleeve chamfer will increase and radial contact pressure will reduce with the increase of the amount of interference. Considering the impact on the taper to the contact, the beginning of the keystone interference has the same situation with no interference 0.1mm taper. With the push carrying on, the axial force decrease rapidly and is higher than the resulting value of no interference 0.2mm taper situations, and the half of the beginning of the keystone interference is the same as the keystone interference, but with the push carrying on, the axial force decrease rapidly and is higher than the resulting value of keystone interference, and is more higher than the resulting value of no interference 0.2mm taper situations. Trapezoidal and half trapezoidal interference generated in the radial interference contact with the contact surface has the same pressure value, and the results are higher than the value under the conditions of no taper affections, and its pressure value is higher up to 40%.

Key words: swing arm; interference fit; interference; taper; keystone interference

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INTRODUCTION

With the social development and scientific progress, people put a higher demand to the living necessities of the car. As an important part of automotive suspension, the swing arm is an important part of the chassis system. Its design and production reliability, security and stability determine the operability and smooth of cars directly, and are related to the safety performance of vehicles. During the design, the swing arm must meet the requirements of the corresponding stress and deformation, avoiding the fracture and plastic deformation because of the local stress concentration. When it comes to the important role that the swing arm has to the safety performance of vehicles, many scholars have been studying about it early [1-5]. It mainly concentrated in the lightweight of the swing arm, design process and its strength, stiffness, fatigue failure etc. What's more, they have a deep theoretical analysis about the assembly interference between the swing arm and sleeve. But the shape of the swing arm and its sleeve is complicated, and driving conditions of the car are different in many patterns, which create that using the traditional method can not analysis the state of the stress and strain exactly. In recent years, with the development of the computer and finite element method, the finite element analysis software can simulate the contact analysis [6, 7]. In this assay, through different interference assembly of the swing arm and sleeve of quasi-static finite element analysis, we can get the interference states in the contract region to provide the basis to the calculation and design of the interference assembly.

EXPERIMENTAL SECTION

Build swing arm and sleeve finite element model

Establish and process of the finite element model

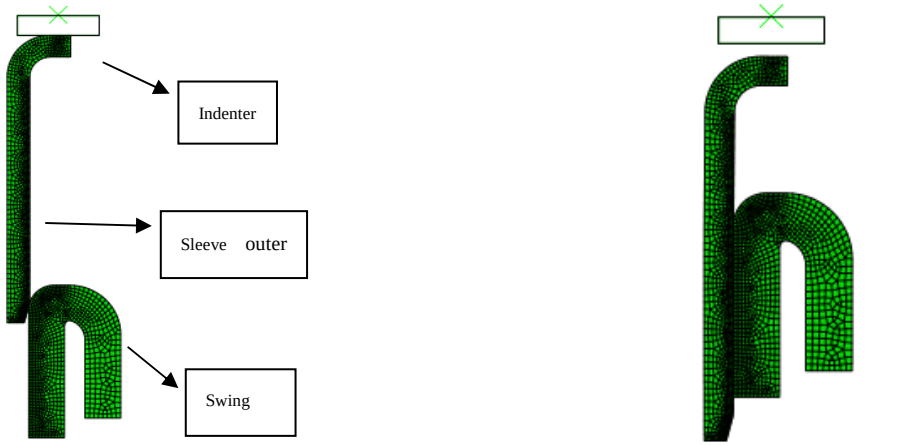
Due to the analysis of the affects that the interference has to the swing arm and the sleeve, we should put attention to

the investigation portion between the swing arm and the sleeve in the position of the contact surface, so we should simulate the model of interference assembly between the swing arms and sleeve. The model which is after the simulation is shown as the figure1 (a). Because the simplified model has the axial symmetry after simulation, we also simulate the model to the axial symmetry which shown in the figure 1(b).

(a) Simplified models **(b) Axial symmetry model**

Figure.1 Simplified models

Quasi-static model is shown in the picture 2, which schedule tentatively that pushing downward vertically is up to 15mm and rebound up to 1mm. Simulate assembly pressed into the entire process. The amount of interference between the outer tube and the swing arm are equal to the difference between the model radiuses.



(a) Beginning of Assembly pushed **(b) Ending of Assembly pushed**

Figure.2 The Contrast of beginning with ending of Assembly pushed

Mesh of the finite element model

The quality of the mesh affect the solution accuracy and computation time directly. So the mesh should be an important link during the analysis process. Considering the simplified model of symmetry and surface contact and other factors, the swing arm and sleeve are meshed in different elements. We put local refinement to the mesh. The patterns and the quantity of the mesh are showed in the form 1.

Tab.1 The type and quantity of the grid

project	Solver unit type	Number of units	Unites Properties
S08	CAX4R	2334	Four node bilinear axi-symmetric quadrilateral element
Axi-symmetric model	CAX3	71	Three linear axes symmetrical triangle junction unit

Material Properties

The material of the sleeve outer tube is the seamless steel pipe of twenty, and the arm is made of Br440, and the properties of the material are set up by national standards.

The contrast of the interference method in the model

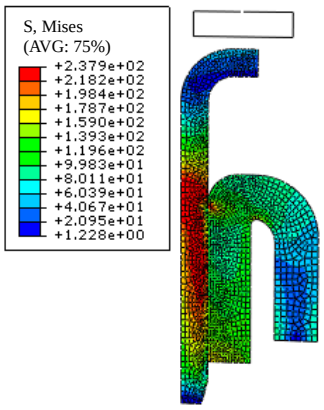
There are different interference methods in the process of building the model. The first category forms interference builds the model and models are closely contact after calculating. Its advantage is that it can create different types of local interference. But the efficiency of work was too cumbersome and slow, we need to change the model after interference. The second category sets the interference between the contacted surface, and it will form cracks

between the models after the calculation is done, and its value is equal to the amount of interference. The advantage is that it is relatively fast to establish different interference over by changing the parameters quickly, but its form is so simple that we can not consider the impact of the taper and so on.

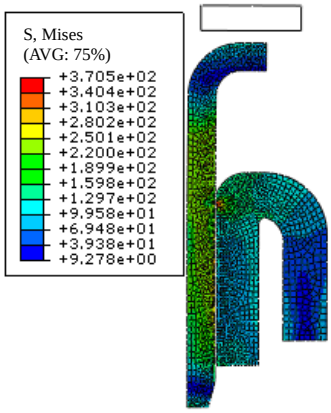
Comparing the results of the two methods above, its peak stress and the stress distribution are basically the same, which illustrates that they are equivalent in essence. Since this article requires detailed analysis about a variety of factors when assembling components interference, we chose the first one.

RESULTS AND DISCUSSION

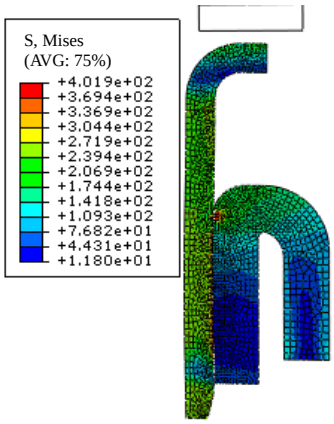
Analyze the mutative process of the axial pressure and radial pressure when the interference is from 0.05mm to 0.25mm, and the quasi-static contact is between the outer tube and sleeve arm. The simulation results under different interference are shown below.



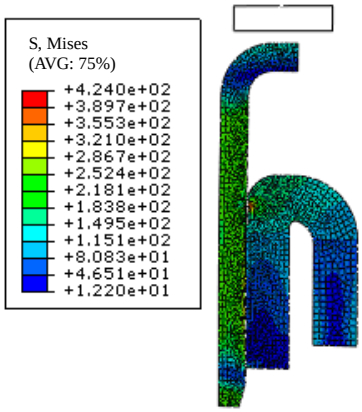
Interference=0.05mm



Interference=0.1mm

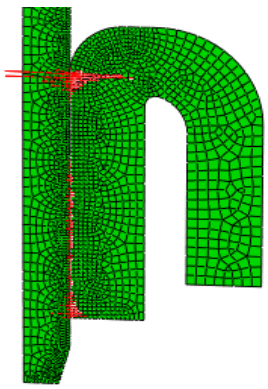


Interference=0.15mm

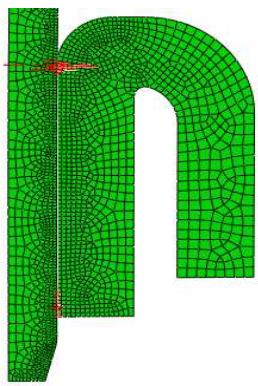


Interference=0.25mm

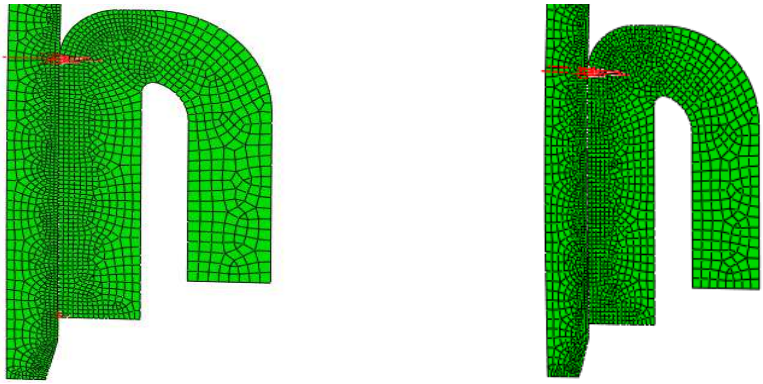
Figure.3The stress distribution under different interference



Interference=0.05mm



Interference=0.1mm



Interference=0.15mm **Interference=0.25mm**

Figure.4 Pressure distribution of radial contact under different interference

We can learn by the simulation analysis of figure 3 and figure 4 that when pressing starts the outer tube chamfer of the sleeve contacts with the arm firstly, and pressure generated in the contact surface increases with the increase of the amount of interference.

The curve of the axial needed pressing into the bush and time is shown as figure 5 and the needed pressing force will increase with the increase of the amount of interference, but its growth trend of force is basically consistent

The relationship between the contact pressure and the time of the swing arm and the sleeve is shown in the figure 6. With the increase of the interference, the radial contact pressure reduces. According to the friction f=μ N, the friction reduces. That is to say, the friction to impede bushings to escape reduces. The sleeve is easy to be prolapsed.

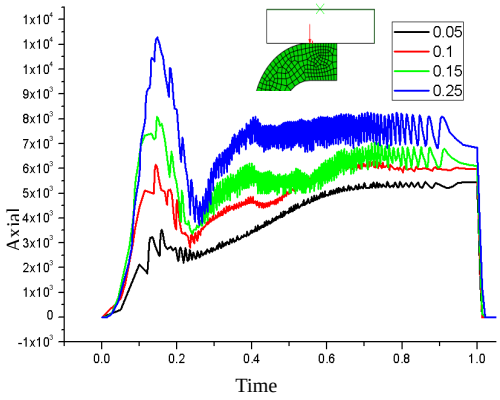


Figure.5 Axial pressure time history curve

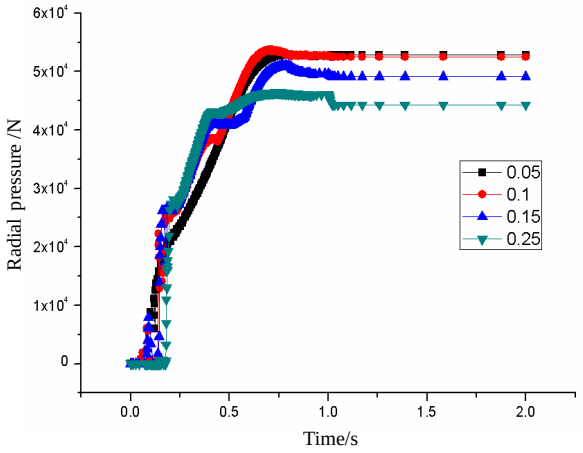


Figure.6 Radial pressure time history curve

There are three types of interference analysis on the impact of different tapers in pushing process. The first type is that the demarcation point is the midpoint, and the parts of the upper are consistent, but the lower part is interference of “right angle trapezoidal”. The second type is whose interference is “a right angle trapezoid”, and the upper interference is 0.1mm and the lower interference is 0.2mm. The third type is that its amount of interference is the same in two parts, which is 0.2mm.

According to the comparison of the results of three types, the axial pressing force trend is shown in Figure 7. We can get the changing course of type 1 and type 2 is basically the same before 0.5s, and the steady-state value of type 1 is biggest, followed by the type 2 and finally the type 3, which demonstrates that the taper has larger impact on the axial pushed force.

According to the comparison of the results of three types, the radial contact pressure trend is shown in Figure 8. We know the changing course of type 1 and type 2 is basically the same, and its steady-state value is over 40% higher than type 3. The radial contact pressure distribution of different types are shown as figure 9, which shows a certain degree of taper may increase radial contact surface area and contact pressure.

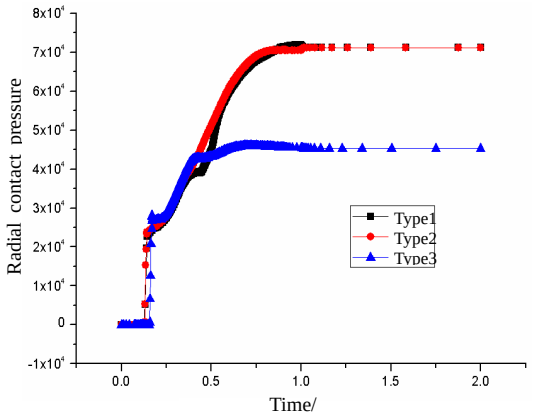


Figure 7 Mutative course of the axial contact pressure

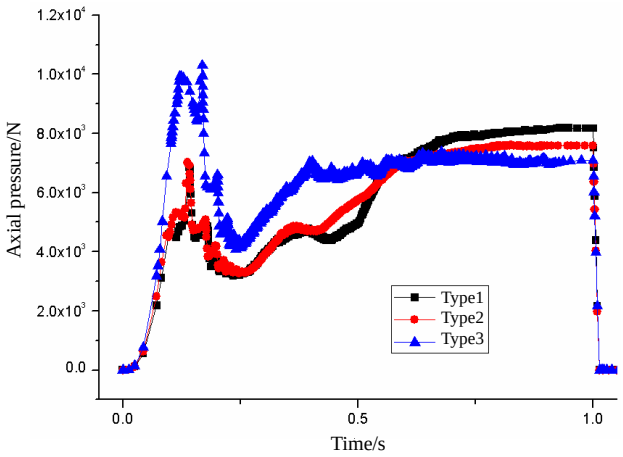
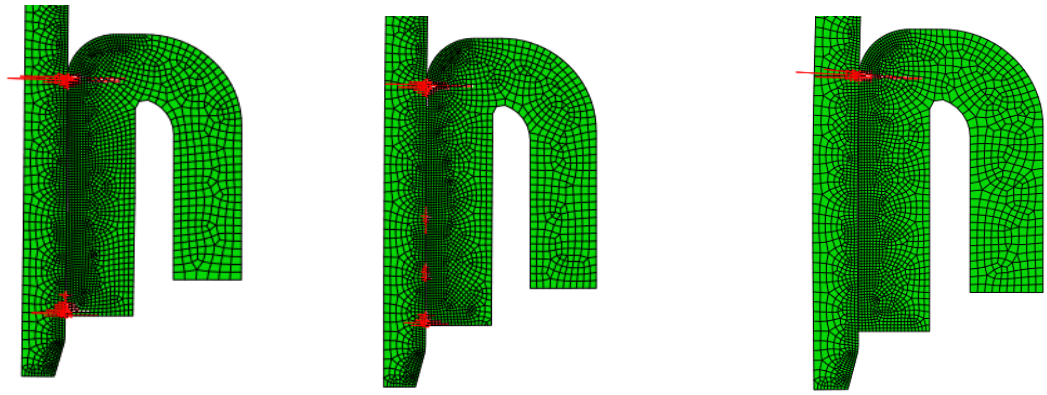


Figure 8 Changes course of radial compressive force



Type 1 **type 2** **type 3**

Figure 9 Different types of radial contact surface pressure distribution

CONCLUSION

Without considering the impact of taper:

(1)The contact surface pressure generated at the outer sleeve chamfer will increase with the increase of the amount of interference.

(2)The axial pressure generated will increase and tend to be steady finally with the increase of the amount of interference. But its value is not equal to the friction ($f = m \mu N$).

(3)The radial contact pressure will reduce with the increase of the amount of interference. Thorough the distributed trends of the radial contact pressure, we can see that the bigger the interference value is, the smaller the effective contact area of the contact force is, and the bigger the interior hollow region is. When the amount of interference reaches a particular value, the contact area only has minimal contact area near the area of the sleeve cuffs.

Considering the impact of taper:

(1)Keystone interference (the upper interference is 0.1mm and the lower interference is 0.2mm): at the beginning, it has the same interference situation as the keystone interference with no taper 0.1mm. As pushed, the axial force decrease rapidly, and is higher than the resulting value with no taper 0.2mm.

(2)Half of the keystone interference (the upper interference is 0.1mm and the lower interference is 0.2mm): at the beginning, it has the same interference situation as the keystone interference. As pushed, the axial force decrease rapidly, and it is higher than the interference resulting value and more higher than the interference resulting value with no taper 0.2mm

(3)Trapezoidal and half trapezoidal interference generated in the radial interference in the contact surface have the same pressure value. And the results were higher than the value without affecting conditions taper and its pressure value is higher up to 40%.

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