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Study on Virtual Simulation Method of Driver Seat Comfort

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Study on Virtual Simulation Method of Driver Seat Comfort

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Abstract. Pressure distribution of the human-machine interface is a key factor which affects the comfort. Because every part of the human body has different tolerance to pressure, high or low pressure will make the driver feel uncomfortable. Through the virtual simulation method combining 3D modeling and finite element analysis, the human body and seat finite element model is established to simulate the interaction of the contact interface, the human-seat coupling model was constructed and finally imported into ANSYS for finite element analysis and compared with the actual measured pressure distribution. The pressure distribution obtained by this method was proved to be feasible for evaluating driver comfort. When apply on seat back comfort study, the changes in the pressure distribution under various conditions can be observed by changing parameters such as seat inclination. The model can be used as a scientific basis for seat comfort assessment and optimization, and the researchers can understand the pressure on the driver's various parts to guide the seat comfort design.

1. Introduction

Users gradually have increasing demands for car comfort, and seating is one of the most important factors affecting driver comfort. Because seats are in direct contact with the human body which possess the complex physiological characteristics, and bringing about the design complexity. The research on the comfort of the foam material is one of the most prominent researches especially.

When the driver is riding on the driving seats, due to the particularity of the human physiological structure, a specific body pressure distribution is formed on the person-chair interface. This form of distribution will change by the factors such as seat stiffness and shape. The body pressure distribution feature is one of the effective objective evaluation methods for seat comfort [1]. Common characteristic parameters are: the average pressure of the human-seat contact interface, the maximum pressure, the contact acreage and the symmetry of the contact area. The above parameters can be obtained by measuring on body-seat contact surface by a body pressure distribution measuring device. However, this method exists the following problems: the problem of repeatability and accuracy is not high enough. Constructing a human-seat coupled finite element model and conducing the comfort simulation through analytical methods is one of the effective ways to solve the above problems.

In this paper, using the virtual simulation method of 3D modeling and finite element analysis, and using ANSYS to build the human body and seat finite element model to simulate the human skeletal muscle system, to analyze the body pressure distribution. The interface pressure distribution characteristics by comparing the simulated and experimental human-seat can indicate that the

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established model can truly reflect the experimental results and provide a scientific basis for the optimiz ation of seat comfort.

2. Establishment of geometric model

The traditional 3D software method of constructing the geometric model can only roughly describe the geometric model of the seat or the human body based on the measured main dimensions, and it is impossible to achieve the purpose of realistically reflecting the surface and shape of the seat or the human body. Therefore, this paper selects the model three-dimensional scanning, and then uses reverse processing to make it into a 3D model to achieve more accurate analysis results. Real objects can be sized by 3D scanning techniques such as CMMS, laser scanners, structured light source converters or X-ray tomography. This paper selects the popular software CATIA to do the reverse processing, which is convenient and flexible.

In the point cloud image obtained by 3D scanning, there are some irregular and abnormal surface changes of the actual seat, such as pits, grooves and the like. In CATIA reverse engineering, it is necessary to reasonably consider the shape of the ideal seat model, combine the actual seat point cloud map, and make reasonable corrections, then conduct characteristic curves, optimize the model details, to make the model to be structured and logic. The principle of modification at this time is to ensure a high degree of similarity between the contact surface of the human body & seat and the actual model, and each part of the curved surface ensures the continuity and approximation of the curvature, while other parts that are not subjected to the body pressure distribution processing are only made into simple flat or spliced surfaces without affecting the simulation results.

The part model formed after CATIA reverse completion is more or less different from the model of 3D scanning, but when the final model result is displayed together with the point cloud image obtained by 3D scanning, the point cloud image can show nearly 50% of the area in the model. The contact surface between the seat and the human body can reflect the contact situation of the two, and meet the reverse requirements. Therefore, the seat model obtained by CATIA reverse is a usable model, which has practical significance.

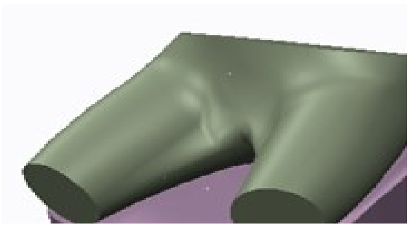


Fig. 1 Assembled drawing of the human body and seat

3. Finite element model analysis

After the geometric model is constructed, the finite element model needs to be constructed in ANSYS, and the pressure distribution characteristics of the human-chair contact interface are analyzed by using the foamed material properties and physical properties, and the feasibility and credibility of the body pressure distribution results can be reflected in the following aspects: (1) the average pressure of the human-chair contact interface (2) the maximum pressure of the human-chair contact interface (3) the size and pressure distribution of the equivalents area of the human-chair contact interface [2]. The construction of the finite element model and the selection of relevant parameters have a significant impact on accurately and truly reflecting the body pressure distribution law of the human chair contact interface.

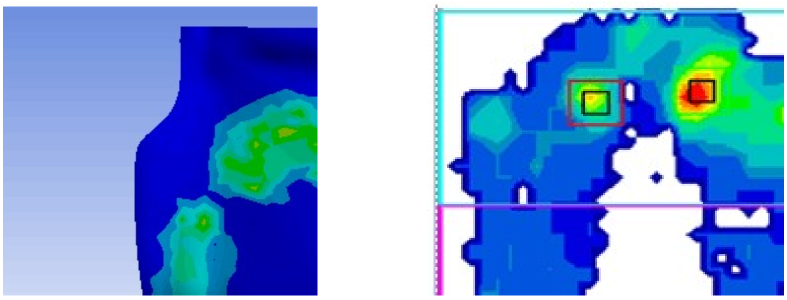
The option of material parameters is the key factor which affects the simulation is successful or not. The reasonableness of the material parameters determines whether the load and deformation are in line with the actual situation. Human body materials are very complicated. It is mainly divided into two parts, skin and bone. The bone model of the bone part is a bone mass adjusted by the rigid structure material (non-deformation). The bone undergoes a small degree of deformation, thus ignoring the effects of the bone. Real human skin is a composite structure composed of various components. According to the mechanical properties of the skin, the skin is approximated as a linear elastic isotropic and approximately compressive material. Since it is difficult to obtain Young's modulus, Poisson's ratio, and the like by stretching a living body, various parameters as shown in Table 1 are obtained by referring to a large number of references [3].

Table 1. Human-Seat model assignment parameter

	Young's modulus	Poisson's ratio	density
Human Body	0.15MPa	0.46	1100 kg/m3
Seat	2.1 MPa	0.3	50kg/m3

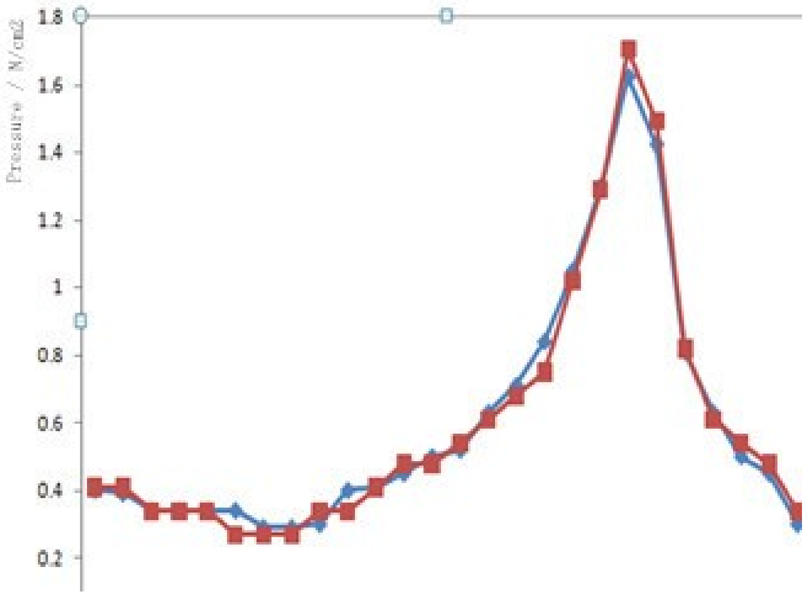
When defining the contact mode, considering that the seat surface is much larger than the human body surface and the body pressure distribution map is displayed on the seat surface, the human buttocks are set as the contact surface and the seat is set as the target surface. Furthermore, the friction factor was set to 0.2, ignoring the interaction of the clothing and the cushion between the skins. When applying a load to the simulation model, in order to compare it with the test results and improve the accuracy of the simulation results, a gravity field is applied to the simulated environment. The human body-seat pressure distribution map (Fig. 2a) is generated, and the buttocks stress is clearly observed to be larger. From the buttocks to the legs, the stress value is gradually reduced, and the overall pressure distribution is uniform. Tekscan CONFORMatTM pressure test pads were used in the experiment to collect the pressure distribution on the seat cushion. There are 1024 (32 × 32) force sensors with a thickness of 1.78 mm on a single test pad, which can measure pressures up to 250 mmHg and the testable area of the test pad is 471.4 mm × 471.4 mm. The actual test results are shown in Fig. 2b.

For further observation, the simulated pressure distribution curve and the measured pressure distribution curve from the front end of the thigh to the longitudinal section of the buttock was conducted (Fig. 3a) and it’s easily to see from the figure that the peak positions of the two pressure distribution curves are almost the same. The pressure values and trends of the various areas of the human-seat contact interface tend to be consistent. Then make the simulated pressure distribution curve and the measured pressure distribution curve on the transverse section of the buttock (Fig. 3b), the pressure changes of the two curves relative to the intermediate point are very similar. The peaks on both sides are in the same position, however, since the right foot is stepping on the brake pedal or the accelerator pedal constantly, the values on the right side of the curve in the figure are larger. The correlation between the two curves in Fig. 3 is very strong, and shows the model created by this method is feasible for evaluating human comfort. The model has certain practical meaning and can be used for further vehicle seat comfort analysis.

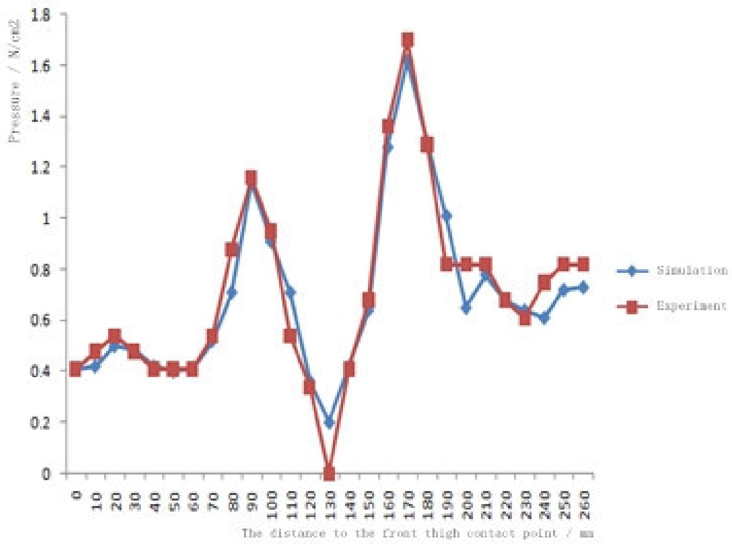


(a) (b)

Fig. 2 a Seat force distribution by software analysis b Seat force distribution by actual measurement



(a)



(b)

Fig. 3 a Pressure distribution curve of the longitudinal section from the front end of the thigh to the buttock**,** b Pressure distribution curve of the buttock transection

4. Application

Based on the method above, the model of the human back and the backrest can also be researched by reversely modeling and coupling analysis. It can be seen from the equivalent stress figure of 3D model that the stress on the back model of human body is mainly concentrated in waist, and there also has a large deformation, with the waist as center, and the stress and strain values gradually decrease from waist to the ends [4].

Because the inclination angle of the seats will affect the construction of the coupled model of the seats, thus changing the simulation results of the finite element analysis, and will affect the force condition. Different pressure distribution profiles are obtained by set the independent variables and parameterized the seat.

4.1. Impact of seats inclination

The actual state of the seat coupled model is changed by adjusting the inclination of the seat, thereby changing the stress and strain distribution. Ensuring other factors remain the same, try to adjust the seat inclination so that the angle of the seat is 15°, 30°, 45°, and the stress distribution is shown in Fig. 4 (e.g. 30°).

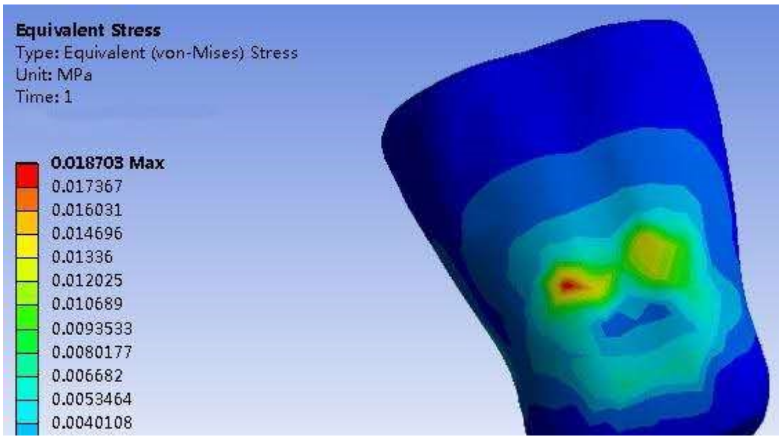


Fig. 4 Pressure distribution of human-seat angle - 30°

As the angle increases, the load-bearing center of the human back gradually moves down. And the total force area of the human back also changes with the angle of the seat. Among them, when the angle of the chair is 30°, the back is more evenly stressed. At the same time, the back of the human body is S-shaped [5], which is "waist support", and the maximum bearing point should be the waist. Therefore, the result shown in Figure 4(c) is most consistent with ergonomics.

5. Conclusion

In the above, geometric model of the car seat is obtained by CATIA. At the same time, the Artec scanner is used to scan the human body and process it into a point cloud model to import into the CATIA to obtain the human geometric model. Then put the two models into ANSYS together and establish the finite element mesh model of the seat and the human body, furthermore, analyze the force of the seat and the human body to obtain the pressure in different areas, and evaluate the comfort of the human body by the pressure distribution after seating. And with changing the parameters of the seats, different pressure changes conditions are analyzed.

It can be concluded that the method can be used as a reliability measure for the comfort evaluation of the driver's seats. In the product design stage, the model can be improved and optimized according to the actual human body-seat pressure distribution law, thereby further enhancing the vehicle seat comfort.

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