

Research on Performance Optimization and Structural Design of Automotive Shock Absorbers

Jinrong Luo, Jiahao Shi, and Xuebing Wang

School of Smart Manufacturing Institute, Chengdu Jincheng University, Chengdu 611731, China

Abstract

As a damping element between the load wheels and the vehicle body, the automobile shock absorber can effectively reduce the amplitude and frequency of vibration generated in the process of traveling, thus helping to extend the service life of elastic components and enhance the comfort of passengers. This study is based on the function and principle of automobile shock absorber, parametric analysis of automobile damping coefficients, reasonable selection of the diameter of the shock absorber working cylinder, and optimization of the design of the shock absorber piston rod, piston and other key components. Rhino software is used for three-dimensional modeling, and finite element analysis is carried out by ANSYS software to verify the performance of the shock absorber cylinder barrel. The results of the study show that the designed shock absorber has a reasonable structure and the performance meets the standard, which can effectively improve the comfort and safety of the car.

Keywords

Shock Absorber Design; Automotive Suspension; Damping Coefficients; Finite Element Analysis; Rhino Modeling.

1. Introduction

In modern society, with the rapid development of industrialization and urbanization, automobiles have become an indispensable means of transportation in people's lives. People's performance requirements for automobiles are increasing, especially in terms of safety, comfort and maneuverability. As a key component of the suspension system, the performance and service life of automotive shock absorbers directly affect smoothness and safety^[1], as shown in Fig. 1, and play a crucial role in absorbing impacts and vibrations caused by uneven road surfaces, reducing the amplitude and frequency of vehicle vibration, prolonging the service life of elastic components, and enhancing ride comfort. Therefore, an in-depth study on the functional analysis and structural design of automobile shock absorbers, as shown in Fig. 2, is of great theoretical and practical significance for improving the overall performance of automobiles.

In the research of shock absorbers, scholars at home and abroad have carried out a lot of work. China has also had a more complete manufacturer and stable material supply chain^[2], under the influence of independent property rights, our automobile shock absorbers have made certain breakthroughs, and some suspension systems are also favored by foreign countries^[3]. Automobile companies start from the smoothness and stability of the whole vehicle, according to the spring loaded/unsprung mass, suspension stiffness, deflection and installation space in the vehicle layout and other specific requirements^[4], optimize the determination of various indicators of the damper at the same time, the multi-body dynamics simulation analysis of the mechanical system in the study of shock absorbers also plays an important role^[5]. Through multi-body dynamics simulation analysis, the dynamic

behavior of the shock absorber in the working process can be understood more deeply, providing a theoretical basis for the design and optimization of the shock absorber.

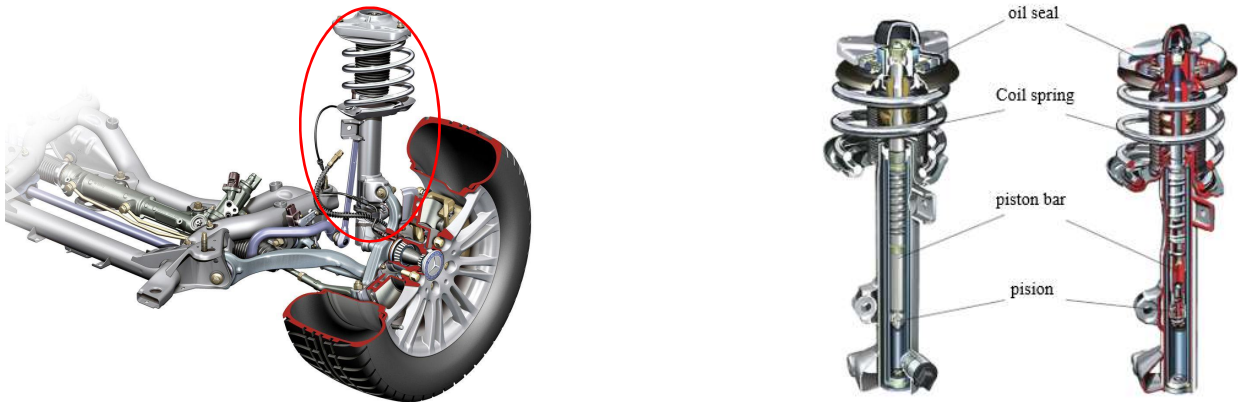


Fig. 1 Vehicle shock absorber mounting position **Fig.2** Internal structure of shock absorber

In this paper, the structure of the automobile shock absorber and its working principle will be analyzed in depth, and data analysis and formula calculations will be used to determine the key dimensions of the shock absorber, and the dimensions of the other parts of the shock absorber will be further determined by QC/T 497-2018, “Performance Requirements of Automobile Shock Absorbers and Bench Test Methods”. The study includes the setting of the shock absorber, the calculation of the damping coefficient, the calculation of the diameter of the working cylinder, the design and selection of the piston part, as well as the three-dimensional modeling by Rhinoceros software and the finite element analysis by ANSYS software. Through the in-depth study of the shock absorber, its role in the automotive suspension system can be better understood and provide a scientific basis for the design and performance optimization of automotive shock absorbers.

2. Shock Absorber Composition and Analysis

2.1 Classification of Shock Absorbers

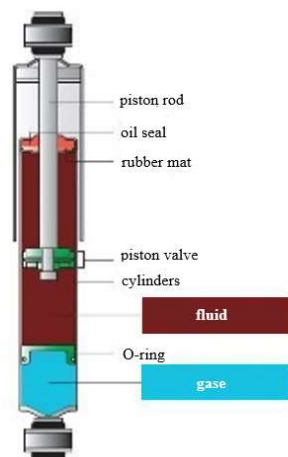


Fig. 3 Single-cylinder shock absorber

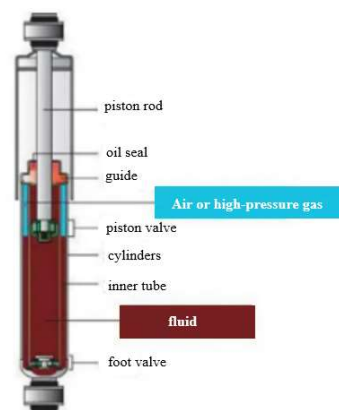


Fig. 4 Double-cylinder shock absorber

Vehicle shock absorbers mainly include two major categories, monocylinder and double-cylinder shock absorbers, whose structural characteristics and practical applications are quite different, and most of the vehicles use hydrodynamic shock absorbers that are filled with liquids in their interiors. As shown in Fig. 3, monocylinder shock absorbers are widely used in economic vehicles due to their simple structure and low cost, however, there are limitations in terms of heat dissipation efficiency

and ride comfort; double-cylinder shock absorbers are favored in high-end vehicles due to their excellent damping effect and handling stability, although their manufacturing cost is higher and maintenance is more complicated, as shown in Fig. 4.

2.2 Composition and Working Principle of Shock Absorbers

Double-cylinder shock absorbers offer higher performance and better comfort for users who seek a high quality ride and handling. As shown in Fig. 5, the shock absorber is composed of several parts, which include the shock absorbing sleeve, oil seal, dust sleeve, spring, guide, upper lifting ring, lower lifting ring, working cylinder, oil storage cylinder, and so on. Each of these parts has its own role, and together they form the working whole of the shock absorber^[6].

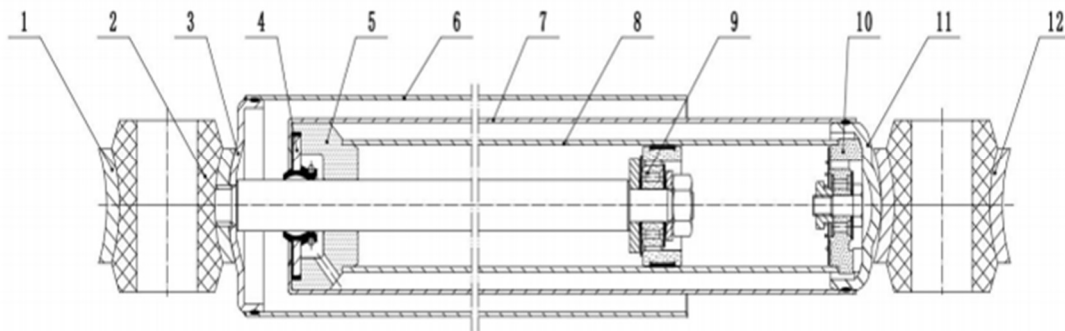


Fig. 5 Structure of double cylinder shock absorber

1-Upper ring 2-Lower shock absorber sleeve 3-Hood cover 4-Guide
5-Oil seal 6-Dust cover 7-Oil storage cylinder 8-Working cylinder

9-Piston valve assembly 10-Compression valve assembly 11-Bottom cover 12-Lower lifting ring

The springs support the bodywork and have the effect of damping. In case of uneven road surface, the spring movement is converted into damping force by the shock absorber, and the hydraulic oil generates heat by friction, which converts the shock energy into heat energy and stabilizes the car body. The shock absorber design needs to balance the compression and rebound damping forces to meet a variety of driving and road conditions, and the driver can fine-tune it by adjusting the interface^[7].

Automotive shock absorbers absorb road impacts through pressure changes in liquids or gases, reducing vehicle vibration and ensuring driving stability and passenger comfort.

2.3 Design Principles for Shock Absorbers

Dampers are designed to reduce the vibration and shock of mechanical equipment under dynamic loading to protect equipment and personnel. Studies have shown that increasing the damping coefficient can suppress body acceleration and wheel kinetic energy, but too high a damping coefficient may reduce ride comfort. In complex environments, the ability of the damper to maintain its expected performance stability is a key indicator of the performance and quality level of the suspension damper^[8].

The design of the damper needs to determine the vibration source and analyze its frequency, amplitude and direction in order to select the appropriate type of spring damper, rubber damper or hydraulic damper; the damper should be installed close to the vibration source, while considering the equipment layout and maintenance space.

3. Design Optimization Solution for Shock Absorbers

3.1 Selection of Automobile Suspension

Automobile shock absorbers are compatible with the suspension system, and the design of the suspension, as a key component connecting the wheels and the body, has an important impact on the stability and comfort of vehicle driving. As shown in Fig. 6, the suspension is divided into two categories: independent suspension and non-independent suspension, in which the independent suspension has the characteristics of independent wheel movement, which is more suitable for modern automobile design.

Independent suspension McPherson suspension structure is simple, low cost and good performance and is widely used in small cars and medium-sized vehicles. As shown in Fig. 7, McPherson-type independent suspension system in the car jumping, its wheelbase and camber change are small, while the quality also reduces the internal camber and wheel camber change is not big, at the same time, because the wheelbase change is also relatively small, so the tire wear rate will be relatively slow [8].

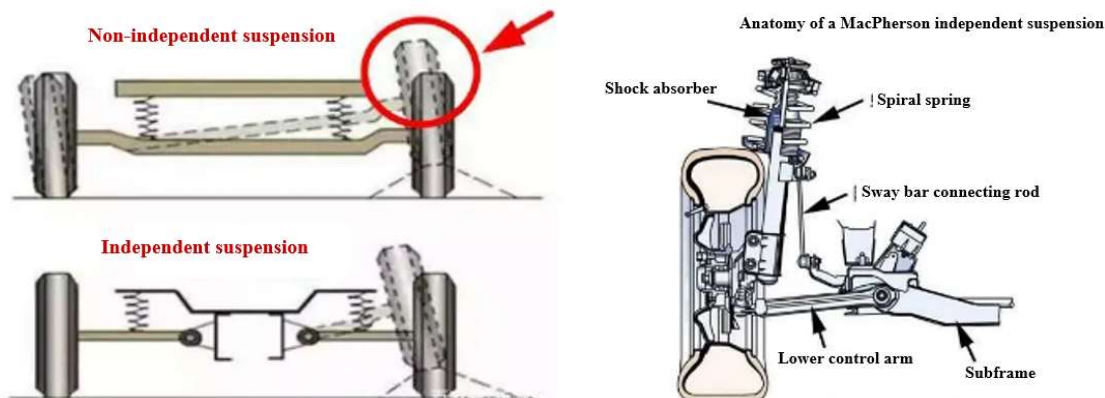


Fig. 6 Independent vs. non-independent suspension

Fig. 7 McPherson independent suspension

Factors such as vehicle usage, speed, load and cost also need to be considered in the selection of suspension. In this study, the suspension types were determined by analyzing the performance of different suspensions, and the advantages and disadvantages of the selected suspensions were analyzed to ensure the matching between the shock absorber and suspension system and the optimization of the overall performance.

3.2 Calculation of Damping Coefficients for Shock Absorbers

For cartridge shock absorbers, parameterization includes the selection of the vehicle suspension, calculation of damping coefficient characteristics and magnitude, suspension stiffness, suspension spring mass, intrinsic frequency of the suspension, maximum unloading force, and relative damping ratio. Among them, the calculation of damping coefficient is a particularly critical step. The damping coefficient is not only closely related to the performance of the shock absorber, but also affected by the installation angle of the shock absorber[8].

For the double-cylinder shock absorber applied to small cars driving in the city, the structure of a certain model of car in Table 1 is taken as a reference to optimize the calculation and validation of some parameters of the automobile shock absorber.

Table 1. Some technical parameters of so-and-so model

Model	Hafei Opinion 1.0L
Wheelbase (mm)	2470
Wheelbase front/rear (mm)	1300/1310
Minimum Turning Diameter (m)	4.75
Overall mass (kg)	1000
Full load mass (kg)	1560
Maximum torque (N-m/rpm)	142/4000
Suspension	Front: MacPherson independent suspension, coil springs with triangulated lower wishbones and lateral stabilizer bar

The damping coefficient is not only closely related to the performance of the shock absorber, but also affected by the installation angle of the shock absorber. Studies have shown that the impact noise between the tire and the road surface can be reduced by about 40% with the proper damping coefficient^[9]. Through the formula and experimental data, the calculation method of the damping coefficient is deduced, and the vibration isolation of the shock absorber is pointed out when the mounting angle is 30°.

Then the damping coefficient is calculated as shown in Equation 1

$$\delta = 2\Psi m_s \omega / \cos^2 \alpha \quad (\text{Formula 1})$$

Preferred we first calculate the suspension static perturbation f_c , you can derive the suspension stiffness C, suspension static perturbation that the car is fully loaded, the stationary state, the suspension load F_w and the suspension stiffness of the ratio of C, Equation 2 as follows

$$f_c = F_w / C \quad (\text{Formula 2})$$

The intrinsic bias frequency of the body can be expressed by Equation 3

$$n = 1 / 2\pi \sqrt{c / m_s} \quad (\text{Formula 3})$$

The suspension static perturbation formula can also be expressed by the formula $f_c = mg/c$, where g is the gravitational acceleration, generally we take 9.81m/s², and by substituting it into Equation 3, we can get Equation 4

$$n = \sqrt{250 / f_c} \quad (\text{Formula 4})$$

The damping ratio ψ , also known as the relative damping coefficient, is often used to determine the magnitude of the vibration weakness, and it is also an indicator that symbolizes the “hard” or “soft” suspension. Its calculation is shown in Equation 5

$$\psi = \delta / 2\sqrt{cm_s} \tag{Formula 5}$$

We can see through the above formula, ψ damping coefficient is bigger then the car vibration kinetic energy weakening faster, but also will be a larger impact force transmitted to the car, ψ damping is smaller is the opposite, the design of the first selection of ψ_s and ψ_y average value ψ , which there is no friction elastic element ψ take the value of (0.25-0.35), there are elastic elements should be taken a little bit, here we will take the value of the damping ratio is 0.3. The intrinsic frequency ω of the suspension system is shown in Equation 6, in which the intrinsic frequency value is generally in the interval of (1-1.45), but according to the actual situation, we should take the intermediate value of 1.3, and at the same time, we can derive the formula $\delta = 2\psi m_s \omega$

Suspension system intrinsic frequency ω formula as 6, which intrinsic frequency value interval is generally in (1-1.45) but according to the actual situation we should take its middle value of 1.3, at the same time, we can derive the formula $\delta = 2\psi m_s \omega$. Then determine the installation angle, other parameters symbols are shown in Table 2, because the shock absorber is not installed vertically with the suspension, but with a certain angle, we get through a large number of experimental data, when the installation angle of 30 °, the vibration isolation performance of the shock absorber is better, and the system stiffness is also appropriate.

$$\omega = \sqrt{c/m_s} \tag{Formula 6}$$

Table 2. Description of formula symbols

Symbol	Meaning	Remarks
δ	Damping factor	
ψ	Relative damping ratio	
m_s	Mass on spring; kg	
ω	Inherent frequency	
C	Suspension stiffness, N/mm;	
n	Front suspension intrinsic bias frequency; Hz	
F_w	Suspension load	
g	Gravity acceleration; m/s ²	9.81

where $\omega = \sqrt{\frac{c}{m}} = 2\pi n$ can be derived from Equation 3, which gives ω equal to 8.16 HZ.

Where the bias frequency takes the value of 1.3, the vertical stiffness of the suspension c is 10.64, substituting into the formula (3-3), the mass m_s on the bullet is taken as 1/4 of the maximum load for 390kg and then substituting into the formula 6, we can calculate the damping coefficient δ for 2250.1NS/m directly.

3.3 Calculation of Working Cylinder Diameter

Calculation of the inner diameter of the working cylinder of the shock absorber In order to determine the inner diameter of the working cylinder, it is necessary to calculate according to the maximum unloading force, the maximum unloading force of the formula 7 is as follows

$$F_0 = \delta_s v_x c \quad (\text{Formula 7})$$

Where: v_x -unloading speed

δ_s -extension damping coefficient

where the unloading speed is as in Equation 8

$$v_x = A\omega a \cos\alpha / n \quad (\text{Formula 8})$$

Where: A for the body amplitude, take the value of $\pm 40\text{mm}$, ω for the suspension vibration frequency, v_x for the unloading speed, generally take the value of $0.15\text{-}0.30\text{m/s}$, stretching damping coefficient of 0.4 .

The speed of v_x is generally taken in the range of $0.15\text{-}0.30\text{m/s}$, here take the value of 0.3m , known as the extension damping coefficient of 0.4 , the suspension stiffness 10.64 substitution of the data to know the maximum unloading force F_0 size of 1276.8N

The diameter of the working cylinder is calculated as in Equation 9

$$D = \sqrt{\frac{4F_0}{\pi[p](1-\lambda^2)}} \quad (\text{Formula 9})$$

Where: λ -ratio of shock absorber working cylinder to connecting rod length

P-Maximum working pressure of working cylinder

Which we work cylinder maximum pressure P can take 4Mpa , λ value with the structure of the different changes in the value of the single-cylinder in 0.3 to 0.35 , double-cylinder in 0.4 to 0.5 we take 0.5 to calculate, then the data will be substituting into the formula 3-6 to calculate the theoretical diameter of the working cylinder of the automobile shock absorber we derived for 23.28mm and through the QC/T491-2018 Automotive cylinder damper size series and technical conditions” in the parameters to determine the diameter of the working cylinder for 30mm , the thickness of the working cylinder for 2mm , Table 3 analyzes the design dimensions of the shock absorber, the material can be selected from 20 steel, 20 steel characteristics are slightly higher. Applicable to the manufacture of automobiles, tractors and general machinery manufacturing industry to build less important small and medium-sized carburizing carbonitriding and other parts, such as automotive handbrake shoes, lever shafts, transmission speeds and so on.

We have calculated the diameter of the working cylinder, the next calculation of the size of the diameter of the oil storage cylinder, in the shock absorber, the thickness of the oil storage cylinder wall needs to be very rigorous, too thin will lead to the cylinder can not withstand the high strength of the pressure transformation deformation and damage, too thick will lead to the cost of the shock absorber weight heavier, not conducive to the dismantling of the work cylinder thickness of 2mm , 30mm in diameter according to Table 3 we can conclude that when the working cylinder diameter of 30mm , the maximum outer diameter of the oil storage cylinder cylinder 46 , the maximum outer diameter of the dust cover 56 . Table 3 we can conclude that when the working cylinder diameter of 30mm , the maximum outside diameter of the oil cylinder cylinder 46 , the maximum outside diameter of the dust cover 56 .

Table 3. Damper design dimensions

Diameter of working cylinder D (mm)	Maximum outer diameter of oil storage cylinder	Maximum outer diameter of dust cover
20	34	49
25	45	54
30	46	56
35	58	70
40	63	75
45	68	80

3.4 Selection of Automobile Suspension

The maximum diameter of the storage cylinder is known to be 46mm, and in order to determine its minimum value, the thickness of the cylinder head when the head has no holes, and the thickness of the cylinder head when the head has holes can be calculated by Equations 10 and 11, respectively.

$$t \geq 0.433D_2 \sqrt{\frac{P_y}{[\sigma]}} \quad (\text{Formula 10})$$

$$t \geq 0.433D_2 \sqrt{\frac{P_y D_2}{[\sigma](D_2 - d_0)}} \quad (\text{Formula 11})$$

Where: t-Thickness of cylinder head; D_2 -Maximum diameter of cylinder head; d_0 -opening diameter of cylinder head; $[\sigma]$ -permissible stress of material; P_y —experimental pressure;

Here you need to set the cylinder head orifice d_0 diameter, that is, the diameter of the piston rod, here set to 20mm, D_2 for the maximum diameter of the cylinder head 46mm, minus the thickness of the cylinder wall 2mm is equal to 42mm. test pressure to take 1.5 times the full load, and will be substituted into the formula 11, can be derived from $t \geq 6.1\text{mm}$

We have arrived at the storage cylinder maximum diameter of 46mm, known as the working cylinder diameter of 30mm, the thickness of 2mm, so the minimum diameter of the storage cylinder cylinder can not be less than 36.1mm. here we set the storage cylinder cylinder outside diameter of 42mm. thickness of 2mm, to meet the $D_c = (1.35 \sim 1.50)D$ according to “Automotive Design”, the material selection of 20 steel, thickness generally take 2.0 to 2.5mm.

Piston rod is the main working element in the steam shock absorber, which needs to work for a long time under high pressure and high temperature, and ensure that it should have enough strength and its surface is smooth. According to GB/T699-2015 can be used using 40, 45, 40Cr and other cold drawn round steel. Its hardness is HRC18 ~ HRC32. take the piston rod material is 45 steel, hardness is HRC18. to forge the piston rod, through the table 4 can get the piston stroke for 110mm to 240mm, we first take the middle value preset for 220mm. automobile's damper piston rod is one of the key components of the suspension damper, in addition to axial and lateral compound force, it will also be subjected to In addition to the axial and lateral compound force, it will also be affected by the friction force, and the - in the table indicates that it is no longer within the travel range.

Table 4. Damper Piston Stroke

Diameter of working cylinder D	Piston stroke S														
	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
20	*	*	*	*	*	*	*	*	*	*	*	--	--	--	--
30	--	*	*	*	*	*	*	*	*	*	*	*	*	*	*
40	--	--	--	*	*	*	*	*	*	*	*	*	*	*	*
45	--	--	--	--	--	*	*	*	*	*	*	*	*	*	*
50	--	--	--	--	--	--	--	*	*	*	*	*	*	*	*

Note: * indicates that in the stroke interval, the unit of the working cylinder diameter is mm.

Since the piston rod material is high-strength alloy steel, it is subjected to complex stress states during its operation. Affected by these forces, the piston rod is prone to strength, deflection and fatigue failure, as well as the failure of oil seals. Therefore, the mechanical properties of piston rods are crucial for automobile driving safety. In order to optimize the mechanical properties of the piston rods and to ensure that they are strong and wear-resistant externally and soft and ductile internally, the surfaces of the piston rods are finely cracked and plated with hard chrome. Since metal plating has good wear resistance, here we metalize it with chrome plating. Usually the external surface of chrome plating is smooth and there should be no pinholes^[11].

3.5 Determination of Other Parameters

In automotive shock absorbers, the piston construction is crucial, integrating components such as shims, compression manifolds, stoppers, nuts, pads and springs. The subtle hole design on the piston stopper ensures unobstructed flow of oil and imposes resistance to realize vibration damping. As shown in Fig. 8, when the piston moves up and down, the oil flows through the slit and the outer hole respectively, showing different flow paths.

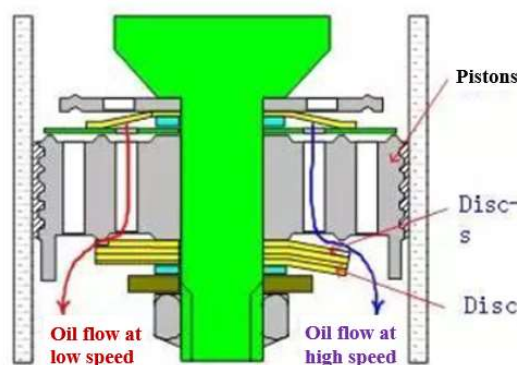


Fig. 8 Piston section

In the automobile shock absorber, the structure of the piston is also very important, the piston consists of many parts, including gaskets, compression valve group, piston block, nut, and pads and springs, in the piston block above the cloth can be circulated holes, and according to the distribution of the location of the gaskets, so that the upper and lower circulation does not interfere with each other, and to the shock absorber piston rod to impose a resistance, in order to achieve the effect of shock absorption.

Too high a temperature and too long a time will lead to a decline in hardness. It is possible to make a cache of its oil. And the structure is designed to be thick in the middle and thin on both sides, and the spring structure is provided to the compression block so that it can move freely to make its work smoother and its design structure is shown in Fig. 9.

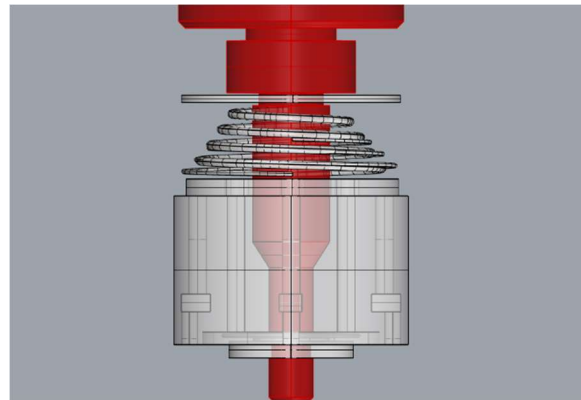


Fig. 9 Sectional view of modified piston

Where the width of the piston should be small with the working cylinder, known as the inner diameter of the working cylinder is 30mm, so the diameter of the piston should be less than or equal to 30mm and greater than 20mm. the piston is calculated as follows in equation 12.

$$D = 2 \times \left(\sqrt{\frac{F}{\pi P}} \right) \quad \text{(Formula 12)}$$

Where: F - the thrust of the hydraulic cylinder

P - the working pressure of the hydraulic system

The maximum pressure of the working cylinder is 4Mpa, the hydraulic cylinder thrust according to Table 5 to take the maximum recovery pressure of 2800, N substituting into the formula 12 can be derived from the piston diameter of 29.84mm, here we directly take 30mm.

Table 5. Resilience and compression resistance values

Work cylinder diameter D (mm)	Resilience (N)	Compression resistance (N)
20	200—1200	≤600
30	1000—2800	≤1000
40	1600—4500	400—1800
45	2500—5500	600—2000
50	4000—7000	700—2800
65	5000—10000	1000—3600

First, the dimensions of the pressure valve holes are calculated, and the pressure valve holes are evenly distributed. The diameter D of the inlet and outlet ports should satisfy Equation 13.

$$D \geq \sqrt{\frac{4q_s}{\pi[v_s]}} \quad (\text{Formula 13})$$

Where: q_s - nominal flow rate of the valve;

$[v_s]$ -permissible flow rate of the inlet and outlet ports, generally take $[v_s]=6\text{m/s}$.

The calculation of q_s is shown in Equation 14

$$q_s = \pi \times R^2 \times v \quad (\text{Formula 14})$$

Where: v -piston speed; generally $0.15 \sim 0.3\text{m/s}$, take 0.3m/s .

Combining Eq. 14 with Eq. 13 yields $D \geq 6\text{mm}$, because under normal circumstances, 8 holes are evenly distributed on the piston, and the total area of the small holes should be equal to the area of the oil inlet and outlet holes. Substituting the data, we can calculate the diameter of the small hole is 2.1mm , here we take 2mm .

The piston diameter is determined by precise calculation to ensure that it can adapt to the working pressure and thrust, meanwhile, the size of the pressure valve hole is also optimized to maintain the appropriate oil flow rate and avoid pressure loss. The piston ring is made of high quality materials such as nylon 1010 and PTFE to ensure excellent sealing performance, reduce internal leakage and ensure damping effect.

In the determination of sealing components and working fluid, the caliber of the selected oil seals is as accurate as 0.2mm to adapt to changing environments; L-HFC hydraulic fluid ensures the smooth operation of the shock absorber even at a low temperature of -40°C with its excellent viscosity, thermostability and low freezing point. The hydraulic cylinder adopts threaded connection, which is economical and efficient, with strong pressure resistance and precise positioning of piston without additional structure; O-ring is selected according to the sealing conditions, and the size is suitable for the working cylinder and the oil storage cylinder.

In terms of the choice of connection structure, the straight lifting ring shock absorber ring was chosen because of its simple structure and high popularity, and the cylinder body was threaded with the end cap [12]. Nitrogen gas inside the cylinder barrel provides stable damping, improves vehicle stability, ride comfort, reduces noise, and extends service life, which has become the key to modern automotive suspension systems^[13].

4. Rhino Modeling and ANSYS Finite Element Analysis

4.1 3D Modeling of Automotive Shock Absorbers

Rhino is a widely acclaimed 3D modeling software in industrial design, known for its accurate model building ability and excellent rendering performance, and is compatible with a variety of file formats^[14].

We use Rhino software, Figure 10 shows the 3D modeling flowchart, according to the design data and structural characteristics of the automobile shock absorber, we firstly draw the individual parts of the shock absorber, such as the cylinder barrel, piston rod and connecting ring, and then assemble these parts into a complete 3D model. Finally, through the rendering technology, we can visualize the overall structure and appearance of the shock absorber, which provides a strong support for the design.

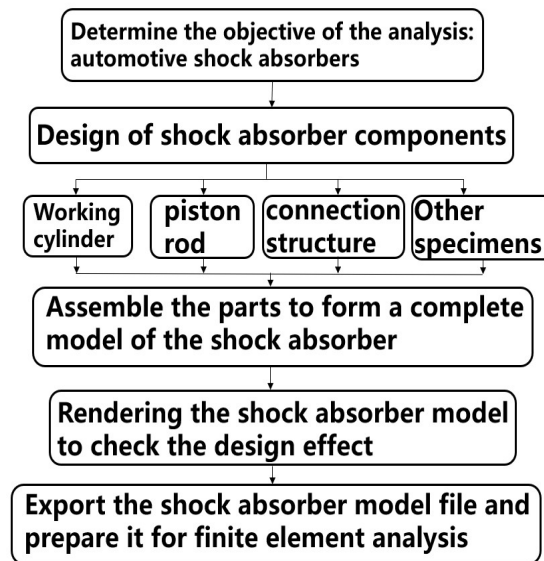


Fig. 10 Rhino 3D modeling flowchart

The modeling is now complete. The overall model of these parts when combined is shown in Figures 11 and 12, along with a rendering of it.

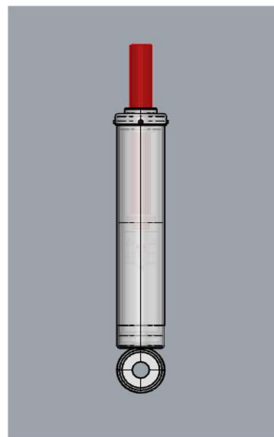


Fig. 11 Shock absorber overall structure



Fig. 12 Rendering effect

5. Conclusion

In order to deeply understand the working strength characteristics of automobile shock absorbers, this paper adopts the advanced finite element analysis technique and conducts a special study on the cylinder barrel, a key component of the shock absorber, with the help of ANSYS Workbench 2022 R1, a world-leading finite element analysis software, which is well known in the engineering and technology circles for its wide range of application fields and excellent performance. ANSYS software is well known in the engineering community for its wide range of applications and excellent performance.

In view of the complexity of the overall structure of the shock absorber, this study selectively focuses on the cylinder barrel part for in-depth analysis. By importing the shock absorber model into the ANSYS software and carrying out detailed meshing, a professional model for finite element analysis is successfully constructed, as shown in Fig. 14, which provides a strong support for the performance evaluation of the shock absorber.

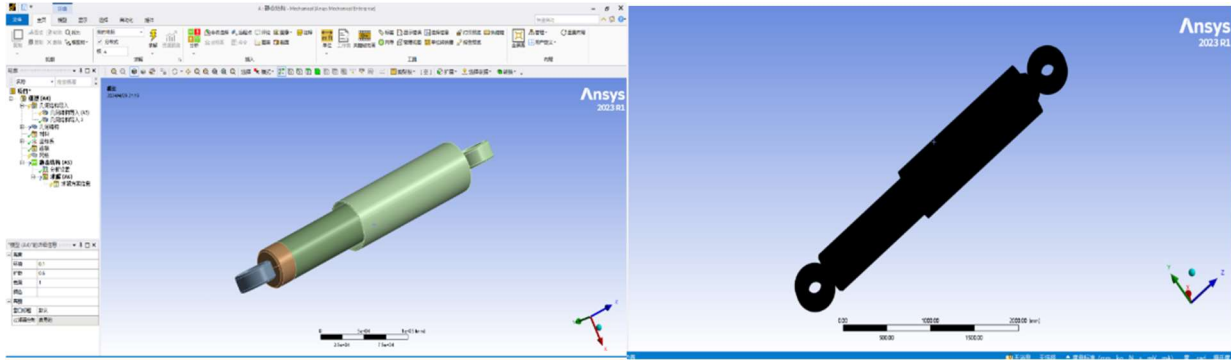


Fig. 13 Imported 3D model

Fig. 14 Overall meshing of the shock absorber

Then the shock absorber piston rod and internal parts are removed and the shock absorber cylinder barrel is analyzed. Here we fix the oil storage cylinder barrel, and then selected its working cylinder material for the 20 steel, thickness of 2mm and then apply a pressure to its internal, as shown in Figure 15, simulate the shock absorber work when the working cylinder pressure, here take the shock absorber working pressure for 3Mpa, the role of the area of 6600mm² of the work of the cylinder under, and 300N.

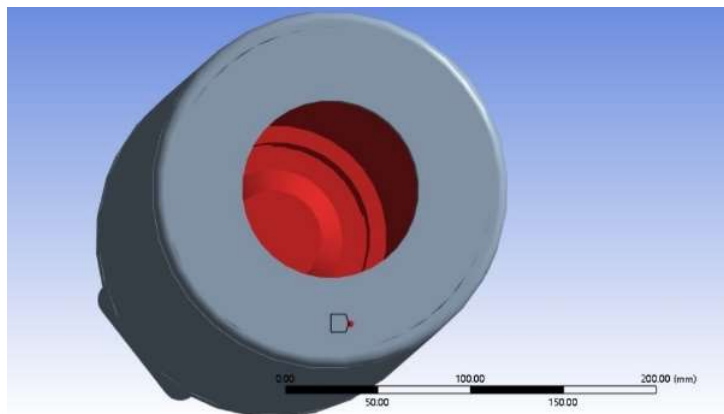


Fig.15 Applying internal pressure to the shock absorber

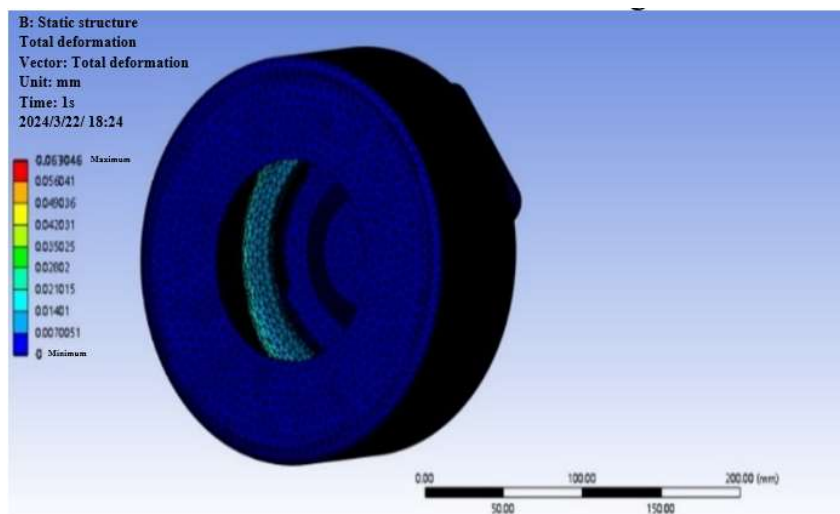


Fig. 16 Shock absorber deformation pressure

Then add the shock absorber fixed point, and force analysis, through its shock absorber internal cylinder deformation to determine whether the shock absorber reaches the standard. Through Fig. 16, we can see that the working cylinder of the shock absorber undergoes a slight deformation after the force is applied, and the deformation is within the controllable range.

In ANSYS software analysis, it is generally considered that a safety factor of 1.5 or more is more desirable for the structure, and the shock absorber cylinder meets the standard by Fig. 17, which yields a safety safety factor of 3 in compliance with the regulations.

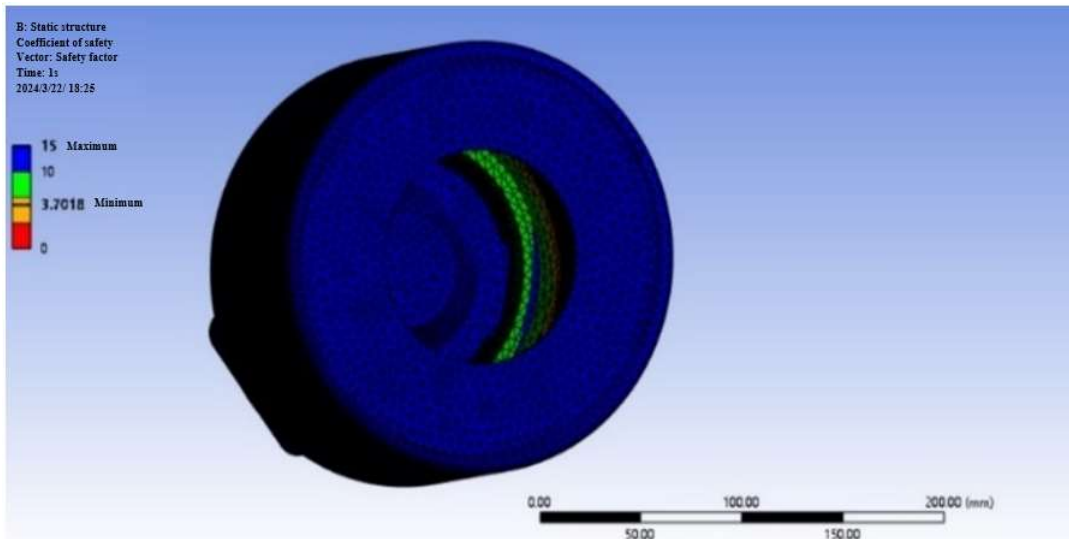


Fig. 17 Shock absorber safety factor

Then the structure of the shock absorber piston Figs 18 and 19 were analyzed, the piston was introduced and then it was fixed and a force of 2800N was applied to its surface, and then the material was selected as No. 45 steel.

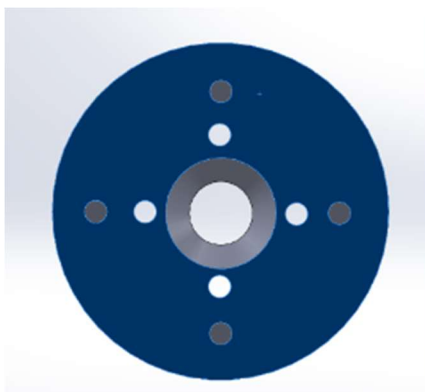


Fig. 18 Piston model

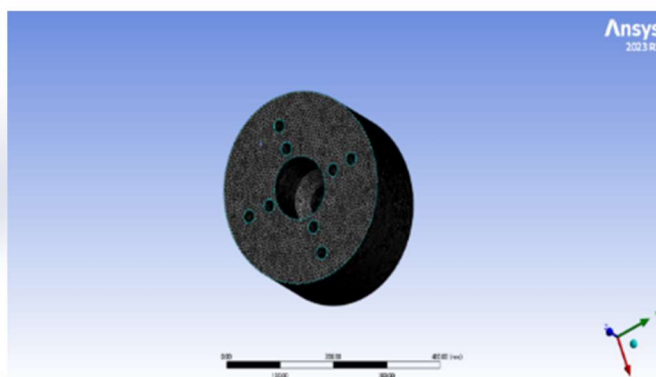


Fig. 19 Gridding

Then it is subjected to force analysis, the 2 sides are fixed as shown in Fig. 20, and a pressure is applied to the surface with a size of 2800N, and then its deformation is observed, according to the force analysis process, the results are shown in Figs. 21 and 22, and its deformation is within the reliable range, and the structure is stable and conforms to the regulations.

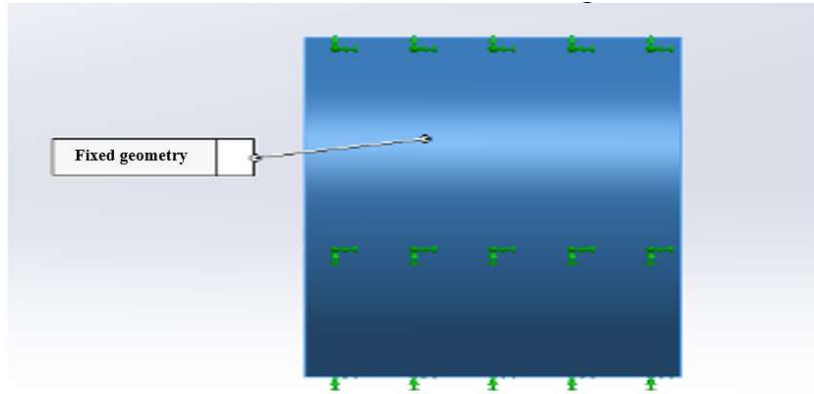


Fig. 20 Adding Fixed Points

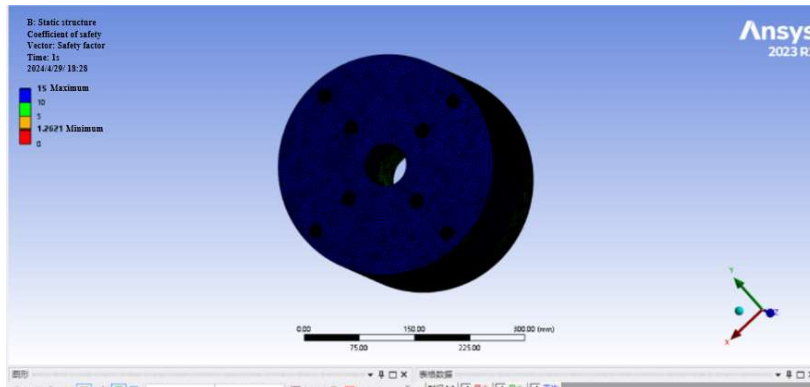


Fig. 21 Safety Factor Chart

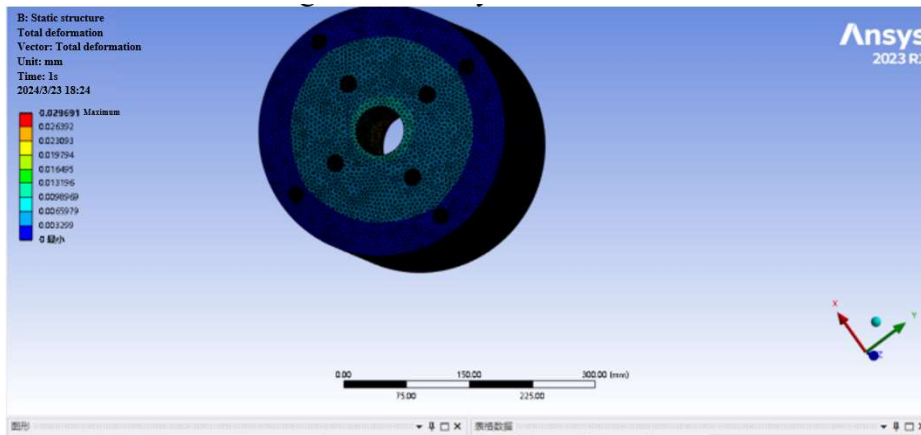


Fig. 22 Force analysis diagram

References

- [1] Na Sun, Jian Zhang, Chang Shen, et al. Technical evaluation indexes for the design and testing of automobile damper safety parts[J]. Shandong Industrial Technology,2015,(20):205-207.DOI:10.16640/j.cnki.371222/t.2015.20.184.
- [2] Ying Dong, Daogang Han.Current situation of automobile shock absorber and its development trend[J]. Internal combustion engine parts,2019,(11):96-97.DOI:10.19475/j.cnki.issn1674957x.2019.11.04
- [3] Chen Wei, JIA Chunsong, Deng Guan, Zhang Guang. Current situation of automobile shock absorber and its development trend[J]. Specialized Vehicle, 2023.

- [4] Yu, D. F., Author. Theory and practice of vehicle suspension damper [M]. Arms Industry Publishing House.2003.
- [5] Xu J. Cylinder shock absorber [J]. Auto Parts,1982,(04):29-30+34.
- [6] Feng zhu, Jiao Qu. Optimized design of double cylinder inflatable hydraulic shock absorber[J]. Digital World, 2016(07):69.
- [7] Pan hong, Brief description of the current situation of automobile shock absorber and its development trend [J]. Science and Technology Innovation and Application, 2014(33):122.
- [8] Enhui Wang, Current status and development trend of automobile damper [J]. Science and Technology Information, 2021, 19(12): 78-80.
- [9] Haizong Gu.Research on the design and performance optimization of automotive shock absorber based on mechatronics[C]//China Wisdom Engineering Research Society.2024 Proceedings of the Academic Exchange Conference on Wisdom Construction and Planning and Design. Jiaxing Yongli Precision Steel Tube Co;,2024:548-551.DOI:10.26914/c.cnkihy.2024.027255.
- [10]Guangjin Zeng, Jinfeng Zhong, Yajuan Wang, et al. Analysis of the effect of shock absorber damping characteristics on automotive suspension performance and noise attenuation[J]. Automotive Repair Technician.2023,(10):116-117.
- [11]Yanan Qiu, Xiaobang Sun, Chunyang Su, Runan Guo. Research on chrome plating process of automobile damper piston rod[J]. Automobile practical technology, 2020, (13): 186-188.
- [12]Feng ZHU, Jiao QU. Optimized design of double cylinder inflatable hydraulic shock absorber[J]. Digital World, 2016(07):69.
- [13]Feihu Guo, Peng Xu, Shuai Han, et al. Analysis of problems in nitrogen commissioning process of cracked gas compressor unit[J]. Petroleum and chemical equipments.2022,25(05):18-20+26.
- [14]Bing Xu,Bing Hu. Design and simulation of automobile suspension damping system based on finite element[J]. Forestry machinery and woodworking equipment
- [15]Yong Xu. FLAC3D modeling method and application based on RHINO-KUBRIX[J]. Shanxi Architecture, 2019, 45(20):94-96.DOI:10.13719/j.cnki.cn141279/tu.2019.20.048.