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Simulation Process Analysis of Rubber Shock Absorber for Machine Tool

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Abstract. The simulation on rubber shock absorber of machine tool was studied. The simple material model of rubber was obtained by through the finite element analysis software ABAQUS. The compression speed and the hardness of rubber material were considered to obtain the deformation law of rubber shock absorber. The location of fatigue were confirmed from the simulation results. The results shown that the fatigue position is distributed in the corner of shock absorber. The degree of deformation is increased with increasing of compress speed, and the hardness of rubber material is proportional to deformation.

1 Introduction

Guideway cover made is an important part of high-speed machine. The vibration of cover made impacts on the accuracy and stability of machine tool. So the rubber shock absorber has an important application in high speed machine[1-2].The deformation conditions is important for the life of shock absorber. Some research works on the rubber materials have been reported. Dynamic compression properties and constitutive model with strain rate effect of rubber material have been studied[3]. Large deformation finite element analysis of rubber isolator has been analyzed[4]. Effect of strain rate on mechanical properties of vulcanized rubber has been researched[5]. Kinetic friction characterizations of the tubular rubber seals has been studied[6]. Thermal stress development of liquid silicone rubber seal under temperature cycling has been analyzed[7]. With the advent of better simulation tools, engineers continue to aim at replicating the complex behaviour in the laboratory, followed by the methods of computer-based, such as finite element[8-9]. A shock absorber is be product by a material of rubber which is elastic type.

In this paper, the simulation of rubber shock absorber is studied. The location of fatigue has been found, and the effect of compression speed and rubber materials on deformation behaviour of rubber shock absorber has been discussed.

2 Experimental procedure

2.1Material property analysis

The deformation of the shock absorber belongs to the large elastic deformation. Therefore, there is a need to have the material uniaxial compression, biaxial compression, plane compression stress and strain parameters, the other did not provide the material of these performance parameters. At present, the performance parameters of the material with shore hardness of 88 and 72 are applied to the simulation. Stress and strain curves of uniaxial compression of materials of 72 and 88 were determined according to the data of the investigation. As many models are necessary to run an assembly performance FEA, there are elastic, elastic-plastic, orthotropic types and so on. In this paper, the numerical modelling of rubber requires non-liner elastic in FEA.

Selected shore hardness 72 of the material as the object, the material used to determine the model for the Ogden model. According to the data fitting, the basic experimental data of rubber mechanics were fitted with Ogden N=3,Fitting of rubber parameters for: μ_1= -201.161, σ_1=10.161,D_1=0; μ_2=114.144, σ_2=11.249,D_2=0; μ_3=95.885, σ_3=17.983, D_3=0. The curve of hardness 72 between fitted and experimental data can be shown in Fig.1.

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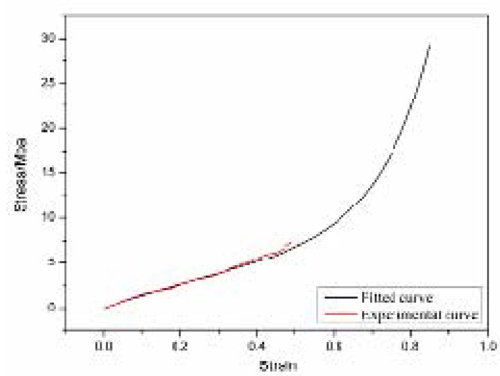


Fig.1. The curve of strain stress of hardness 72 rubber

2.2Modeling Building

According to the force of the shock absorber, Put the data into the ABAQUS software, and then a shock absorber in numerical simulation under load alternating. The model is simplified, and the model is shown in Figure 2:

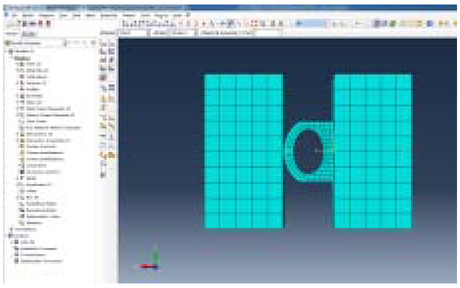
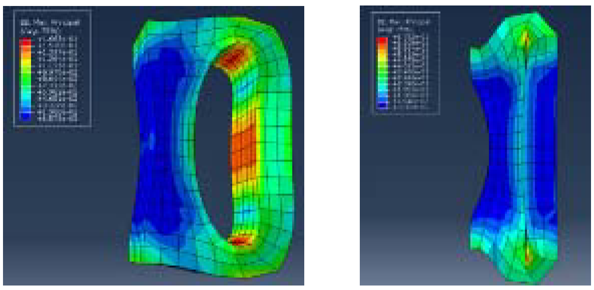


Fig. 2. Compression model of shock absorber

3 Result analysis

3.1Change trends of observation points of shock absorber



(a) Compression process (b) Compression end

Fig. 3. Elastic strain of the compression process of the shock absorber

Strain variation in the deformation process of the material is shown in Fig 3. According to compression process, material deformation distributions for some different can be seen in the upper part and the two sides of the cushion deformation is relatively large, the force analysis of shock absorber is obtained based on the deformation of the two sides. According to the compression of the shock absorber set two points as the observation point, its observation position as shown in figure 4.

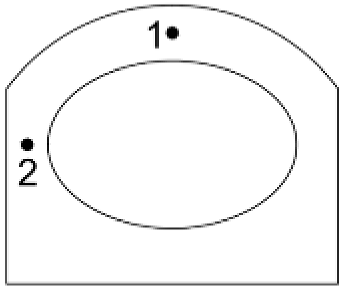


Fig. 4. Schematic diagram of the observation position

The changes of stress and strain at different compression positions are shown in Figure 5 and Figure 6, respectively. It can be seen that the stress and strain are first increased with the change of the compression stroke, and the performance is tensile stress. After reaching a vertex position, the rate of increase is slowed down. It is deeply related to material hardening caused by compress in deformation process.

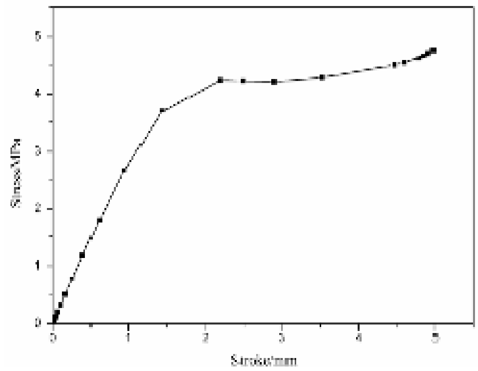


Fig. 5. Stress-stroke curve of point 1

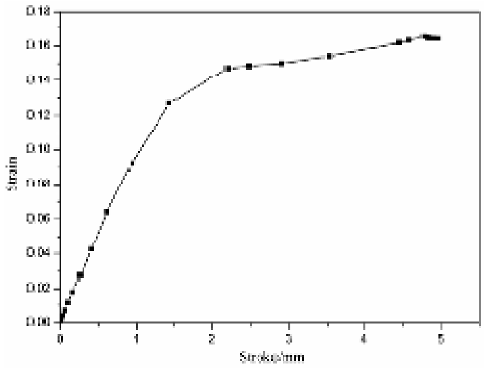


Fig. 6. Strain-stroke curve of point 1

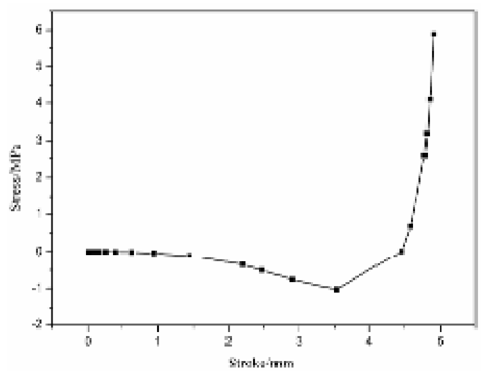


Fig. 7. Stress-stroke curve of point 2

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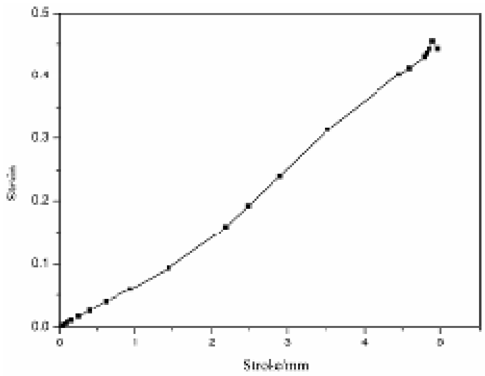

Fig. 8. Strain stroke curve of point 2

The changes of stress and strain at different compression positions are shown in Figure 7 and figure 8, respectively. It can be seen that the observation point 2 is first subjected to tensile stress in the compression process, With the increase of compression stroke, when the stroke is about 3.5mm, the maximum value of tensile stress is reached. As the compression stroke continues to increase, the observation point 2 gradually changed to compressive stress. And the compressive stress increases with the increase of the compression stroke at a faster acceleration. The strain has increased linearly with the effect of compression speed on the performance of shock absorber.

As shown in Figure 9 and 10 for the shock absorber speed of 60m/min and 120m/min, the shock absorber hardness is 88, the deformation of the observation point 2.

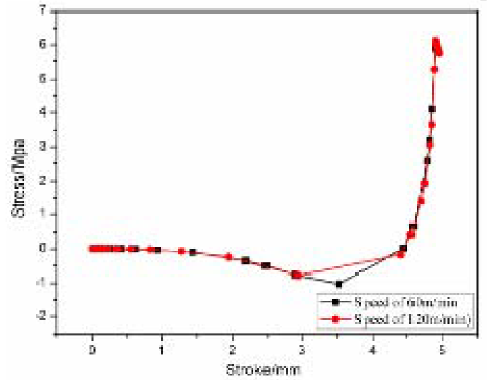

Fig. 9. Stress stroke curve under different compression speed

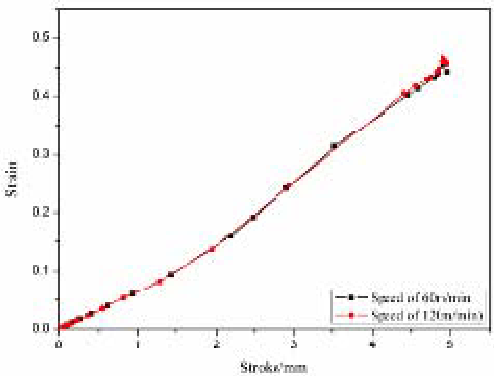

Fig. 10. Strain stroke curve under different compression speed

It can be seen from the figure above, the compression speed of the shock absorber is consistent with the change of the material, that is, the speed is different, the performance of the material is not affected by the change of the trend.

3.2 Effect of materials on the performance of shock absorber

The changes of stress, strain and compression stroke of materials with different hardness at the observation point 1 are shown in Figure 11 and 12.

From the figure 11 and 12, we can see that the hardness of the rubber material is consistent with the influence of the compression deformation of the shock absorber, the difference is that the higher the hardness, the greater the stress and strain in the deformation process.

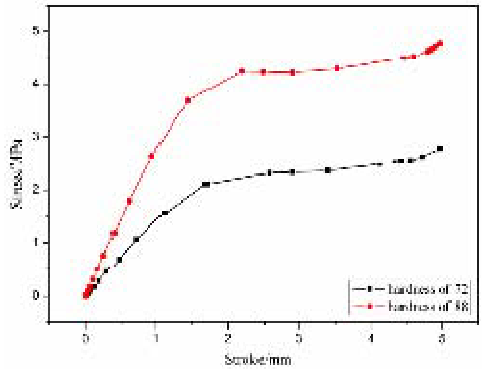

Fig. 11. Stress stroke curve with different material

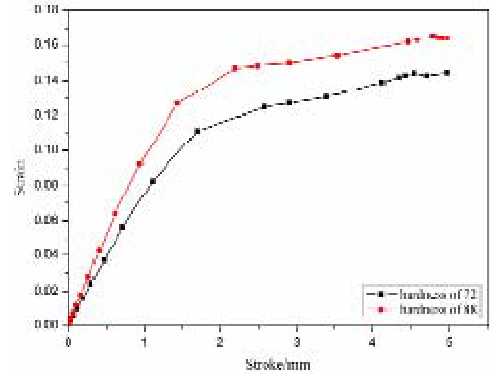

Fig.12. Strain stroke curve of shock absorber with different material

3.3 Effect of observation position

The different observation points at the speed of 120m/min under the compression process of the deformation for the material hardness of 88 as shown in figure 14 and 13.

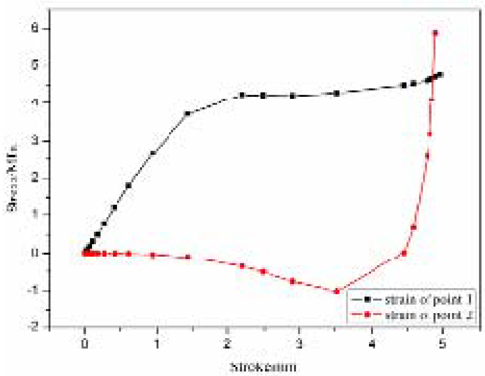

Fig. 13. Stress stroke curve of the shock absorber with different material

According to figure 14 and 13, it can be seen that Point 1 in the deformation process has been in the compressive stress, and the stress has been increasing, the point 2 is the first compressive stress. With the gradual increase of deformation, the point 2 is subjected to compressive stress. The stress of the point 2 should be greater than the stress of the point 1. It can be seen that the point 1 of the strain gradually increased to a certain amount, it showed a slow growth trend. The strain at point 2 appears to increase rapidly with acceleration.

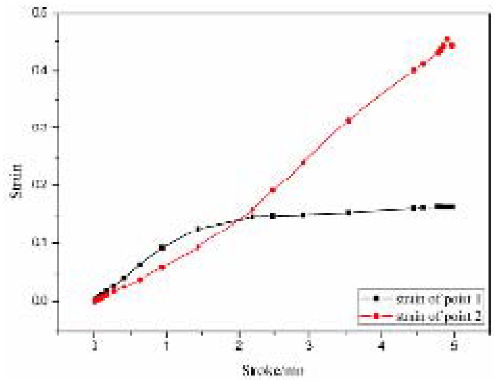

Fig. 14. Strain stroke curve of shock absorber with different material

4 Conclusions

(1) According to the simulation results, we can know that the speed of machine tool has no obvious impact on the deformation degree in the course of operation foe the shock absorber.

(2) In the simulation process, the risk point is in the edge position of the shock absorber. So the failure of the shock absorber can be determined according to the deformation of the risk point during the operation of machine tool.

(3)The same material, the hardness is not the same, for a higher hardness of material deformation resistance is also bigger.

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