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The comparison of experiments and mathematical model of mono-tube dampers **XINXIN HE**

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Introduction

A damper is an important part of the suspension system which can prevent road shocks from being transmitted to the vehicle component and the passengers and preserve the stability of vehicles while in motion.

Dampers' function in this system is to dissipate the excess dynamic energy of vehicles. There are different types of dampers such as the viscous dampers, elastomer Dampers, hydraulic dampers and so on.

Project Aims

The mono-tube damper is a basic damper containing all the important components of a hydraulic damper. The project aims to build the mathematical model of the monotube damper, and compare the results of this model with the results of the physical experiments, and finally figure out the influences of the oil viscosity and temperature.

Methodology

There are two main parts of this project. The first one is to build the mathematical model which is performed by analyzing the flow of oil and the force applied to the piston during the working process. The physical model is shown in Figure 2. Moreover, some previous studies provide some information and advice to this project. There are some formula used in this project.

- Orifice flow

$$Q = c_d A_T \sqrt{\frac{2*\Delta p}{\rho}}$$

- When the gas temperature is constant, the pressure and volume of gas satisfy

$$P_1V_1^n = P_2V_2^n = C, \quad n = 1.4$$

- The second law of Newton: F=ma

The second part is to evaluate the mathematical model and figure ou the influence of the oil viscosity and temperature. Different results of the mathematical model are compared with the results of the physical model to evaluate the accuarcy of this model. Some advice is given to improve the accuracy of the model. The influence of oil viscosity is discussed by comparing the results of physical experiments and mathematical model using different viscosity value while keeping other condition the same.

Figure 1. The mono-tube damper used in the experiments.

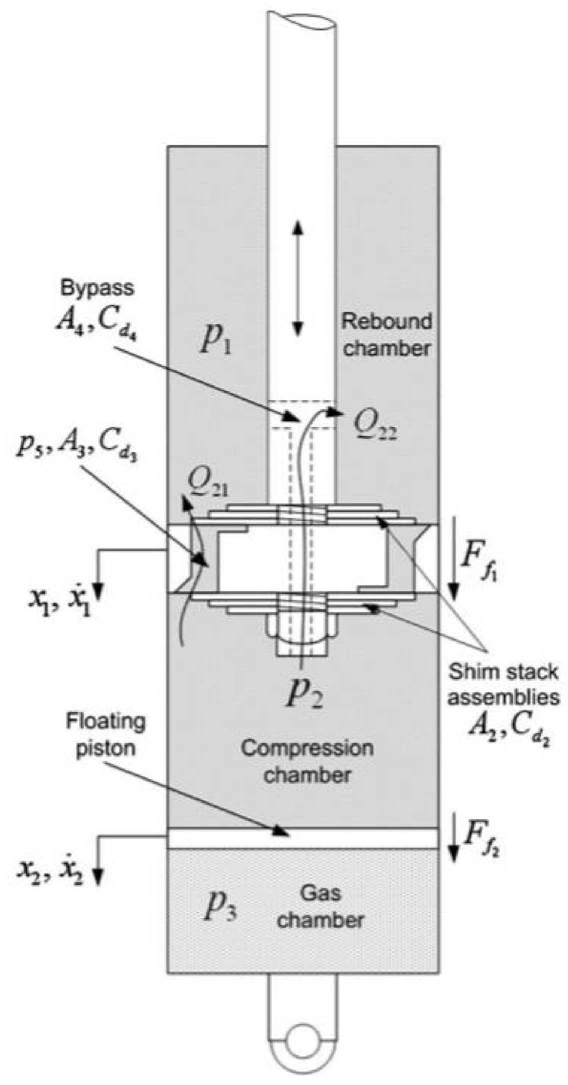

Figure 2. The physical model to analyze the damping force of a mono-tube damper during the working process. Photo reproduced from [1].

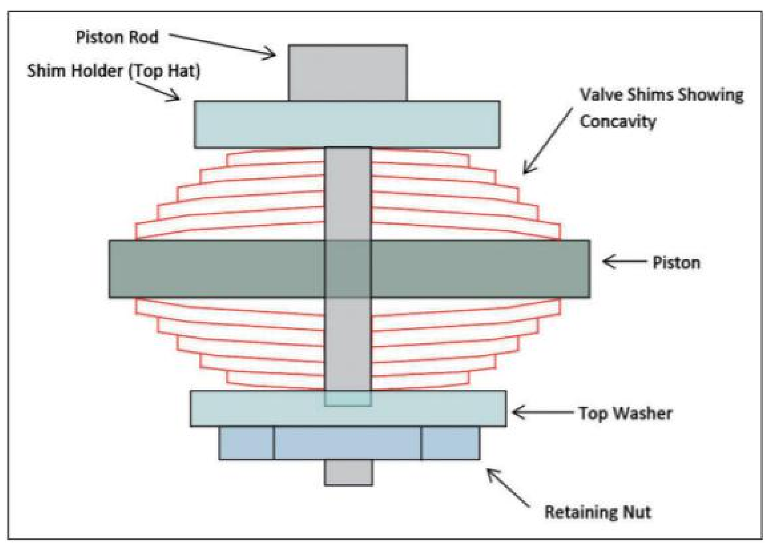

Figure 3. A simplified structure figure of the shim stack which can influence the cross-section area of dampers' orifice. Photo reproduced from [2].

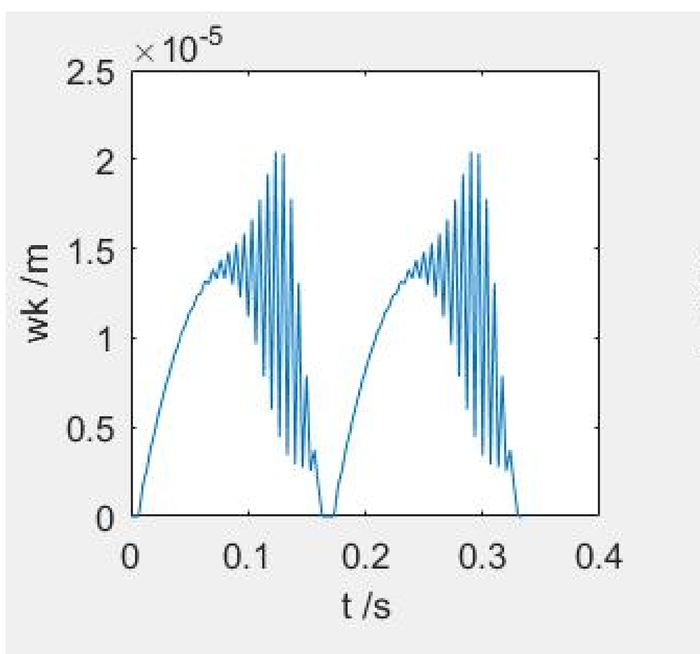

Figure 4. The deformation of the shim stack calculated by the programme .

Results

The results of the mathematical model are shown in Figure 4 and 5. The experiment result is shown in figure 6

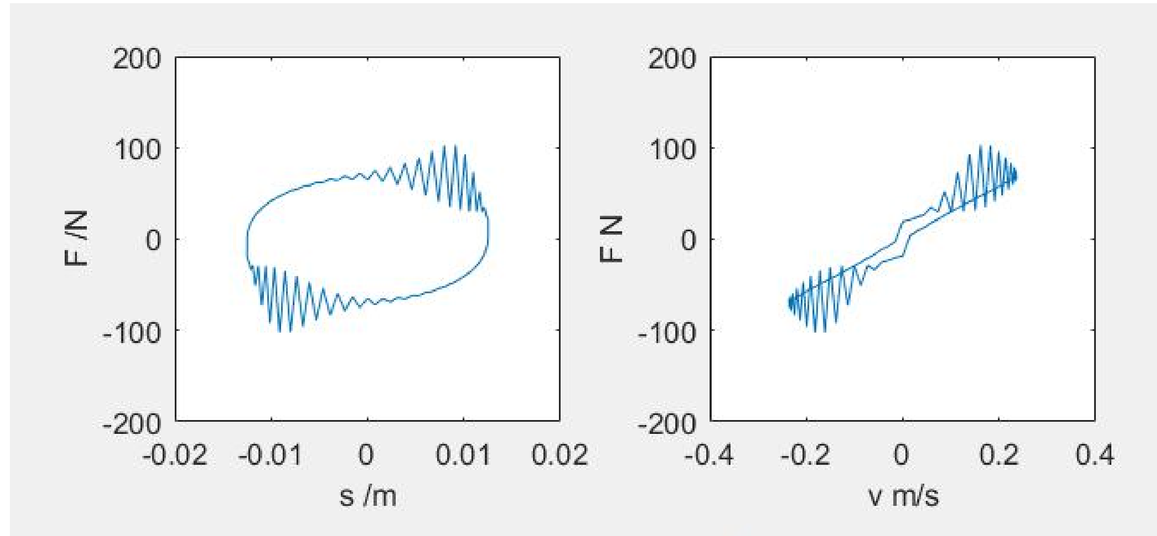

Figure 5 The result of the mathematical model, calculated by Matlab programme. The relationship between damping force and velocity and time.

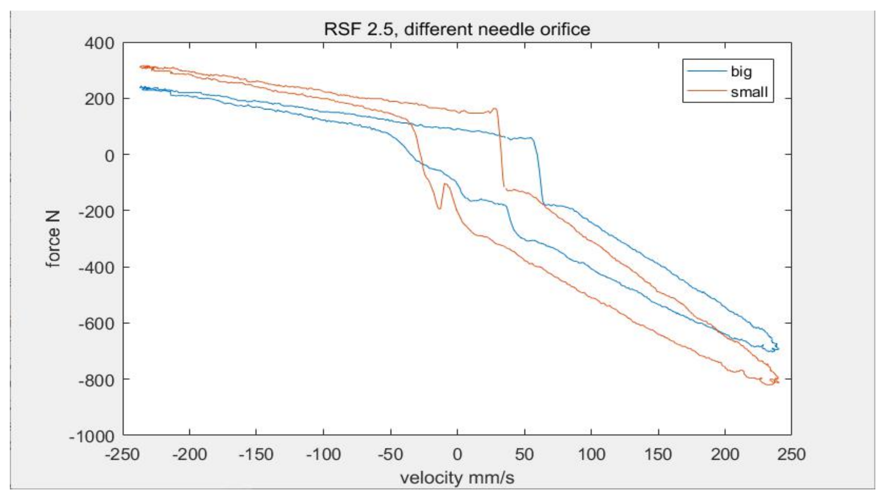

Figure 6. The relationship between velocity and damping force.

Conclusion

This project built a mathematical model for the monotube damper. It is not as accurate as experiments tests and there will be some oscillation in the results of the model which can be improved by using a feedback control in the model. The thicker the oil, the bigger the damping force under the same condition. Temperature can influence the damping force by influencing the oil viscosity

Acknowledgements

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References

[1]Farjoud, Alireza, et al. (2012) "Nonlinear modeling and experimental characterization of hydraulic dampers: effects of shim stack and orifice parameters on damper performance." Nonlinear Dynamics 67.2 (2012): 1437-1456..

[2]Bell, D., and R. G. Beale. (2017) "Numerical investigation of a mono-tube damper with a shim stack." Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science 231.9 (2017): 1762-1774.

[3]Warring, R. H. (1983) Hydraulic Handbook. 8th. ed. Trade & Technical. Print.

MATLAB

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