Application of FluidSIM Software and Project-based Cases in the Teaching of Hydraulic and Pneumatic Transmission

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Abstract. With the rapid development of automation technology, hydraulic and pneumatic transmission, as an important part of mechatronics system, has been widely used in various industrial fields. In order to improve the teaching effect of hydraulic and pneumatic transmission course and cultivate students' practical operation ability, this paper discusses the application of FluidSIM software combined with project-based case teaching method in hydraulic and pneumatic transmission course. By analyzing the characteristics and teaching needs of FluidSIM software and combining the advantages of project-based case teaching, it is proposed how to effectively combine the two in the teaching process, improve students' practical ability and innovation ability, and provide theoretical and practical basis for cultivating compound technical talents in the field of hydraulic and pneumatic transmission.

Keywords: hydraulic and pneumatic transmission, FluidSIM software, project-based cases

1 Introduction

Hydraulic and pneumatic transmission systems are core components of modern mechanical equipment and are widely used in engineering machinery, automated production lines, aerospace and other fields [1]. Traditional hydraulic and pneumatic transmission courses mainly rely on classroom explanations and experimental operations, but due to the complex principles involved and expensive experimental equipment, students' understanding and hands-on ability are often limited. In order to effectively solve these problems, the use of advanced teaching tools and methods has become the key to improving teaching quality. FluidSIM software, as a professional hydraulic and pneumatic transmission simulation software, can help students better understand the principles and applications of hydraulic and pneumatic transmission through system design and operation in a virtual environment [2]. Combined with the project-based case teaching method, it can not only improve students' theoretical knowledge, but also enhance their practical operation and problem-solving abilities [3].

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2 Application of FluidSIM Software in Hydraulic and Pneumatic Transmission Teaching

FluidSIM software is a powerful hydraulic and pneumatic transmission simulation tool with an intuitive graphical interface and a rich component library. In teaching, FluidSIM software can be used to build virtual circuits, perform system simulation and parameter adjustment. Through simulation, students can intuitively observe the working principle of the system and the action process of components, and deepen their understanding of theoretical knowledge [4]. In addition, FluidSIM software also supports fault simulation functions, which can help students develop fault diagnosis and troubleshooting capabilities.

Compared with traditional teaching methods, FluidSIM software has significant advantages. It provides a safe and convenient experimental environment where students can conduct various experiments without touching actual equipment. FluidSIM software also allows students to freely adjust system parameters and observe system responses, which helps students understand the impact of parameters on system performance. The simulation results of FluidSIM software are intuitive and accurate, which can help students better understand the design principles and operating characteristics of hydraulic and pneumatic transmission systems, and can perform system design, operation and fault diagnosis without expensive experimental equipment [5]. In the hydraulic system, after the electrical control circuit and the hydraulic circuit are connected, the simulation can be performed immediately. If there are problems with the electrical circuit and the hydraulic circuit, the software can automatically report an error. Therefore, during the class, electrical knowledge and hydraulic knowledge can be combined to enable students to conduct comprehensive training in electrical and hydraulics, and improve the "electromechanical and hydraulic" innovation comprehensive ability of students majoring in mechanical and electronic engineering, mechatronics technology, etc. [6].

2.1 Single-acting Hydraulic Cylinder Reversing Circuit

The single-acting hydraulic cylinder reversing circuit consists of a metering pump, a relief valve, a reversing valve, an oil tank, and a single-acting hydraulic cylinder. Since the single-acting hydraulic cylinder has only one oil port, the piston is pushed in one direction by hydraulic oil, while the return stroke is achieved by spring force or external force. Therefore, the core of the single-acting hydraulic cylinder reversing circuit is to achieve the extension and retraction of the hydraulic cylinder by controlling the on and off of the hydraulic oil.

The working principle is as follows: Since the single-acting hydraulic cylinder has only one oil inlet, when it is not working, the reversing valve is in the normal position and the hydraulic cylinder does not extend. When the button S1 is activated, the coil K1 is energized and maintained, driving the 1Y1 solenoid valve, the reversing valve is switched to the right position, and the pressure oil output by the hydraulic pump enters the rodless chamber of the hydraulic cylinder through the reversing valve, pushing the

piston upward, and the hydraulic cylinder extends back. When the normally closed contact S2 is pressed, the system stops running, 1Y1 is not energized, the reversing valve is switched to the normal position, and the piston in the hydraulic cylinder can be retracted by external force or deadweight.

After completing the design of the hydraulic system electrical control circuit and hydraulic circuit, click the start button in the menu bar to enter the simulation mode of FluidSIM software. Move the mouse to the normally open button S1 in the electrical control circuit. When the pointer changes to a hand shape, the single simulation button can enter the simulation state. During the simulation process, the user can monitor the pressure, flow, hydraulic cylinder movement speed and other performance parameters of the hydraulic components of each pipeline in the control circuit in real time, and can view the state diagram of the working process and time relationship of each component in the system [7]. As shown in Figure 1-2 below.

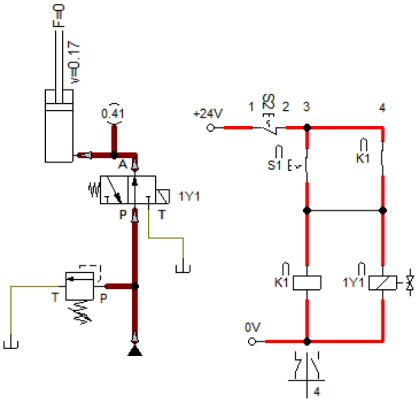


Fig. 1. Reversing circuit diagram of single-acting hydraulic cylinder

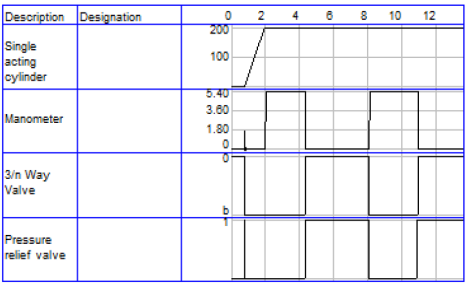


Fig. 2. Working process and time diagram of hydraulic element

It can be seen from the figure that the single-acting cylinder extends to the end after 0.25s, and the pressure on the pressure gauge is the pressure value set by the overflow valve, 5MPa. When the button S1 is pressed, the pressure value of the system is 0MPa. It can be seen that the relationship diagram can truly reflect the actual working conditions of the hydraulic system.

2.2 Double-acting Hydraulic Cylinder Reversing Circuit

The double-acting hydraulic cylinder reversing circuit consists of a metering pump, a relief valve, a reversing valve, a hydraulic cylinder, and a one-way throttle valve. The working principle is: when the switch S1 is pressed, the normally open contact K1 is closed, the electromagnetic coil 1Y is energized, the reversing valve is reversed, and the high-pressure oil in the hydraulic pump passes through the reversing valve and the throttle valve and enters the rodless chamber of the hydraulic cylinder, pushing the piston to extend. When the switch S1 is opened, the high-pressure oil output by the hydraulic pump enters the rod chamber of the hydraulic cylinder through the normal position of the reversing valve, pushing the piston to retract, as shown in Figure 3.

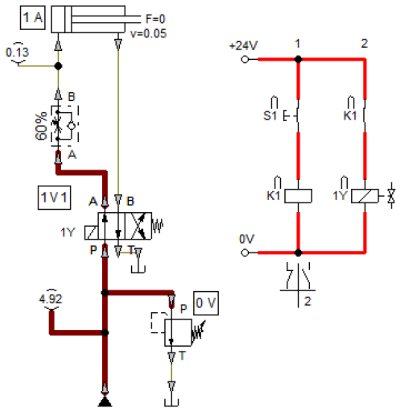


Fig. 3. Diagram of the reversing circuit of a double-acting hydraulic cylinder

The operating speed of the actuator can be affected by changing the opening size of the one-way throttle valve and the external load. At the same time, the speed of the actuator will also vary depending on the throttle valve opening. With the help of FluidSIM simulation software, students can accurately set the throttle valve opening and load, and intuitively observe the changes in various parameters, which is conducive to a deep understanding of the load characteristics of this circuit, as shown in Figure 4 below.

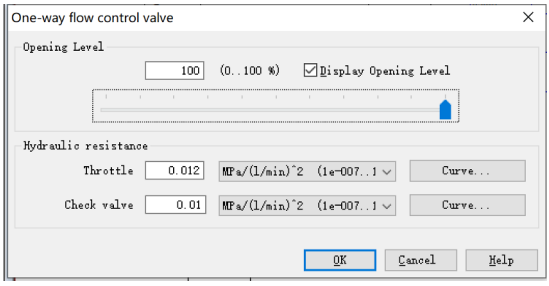
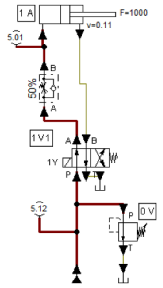
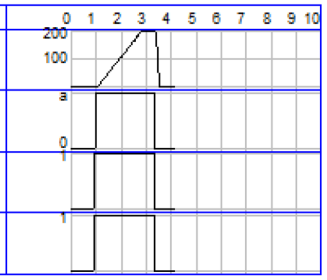


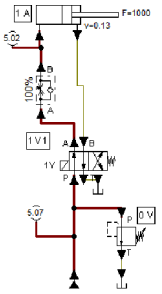
Fig. 4. Hydraulic component operating parameters



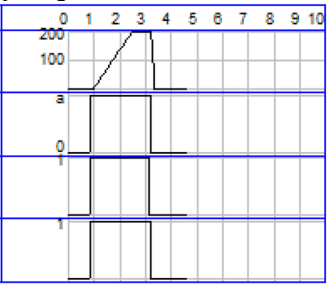
Description	Designation
Double acting cylinder	1A
4/2-way solenoid valve	1V1
Pushbutton (make)	S1
Make switch	K1



(a)Throttle valve opening 50%



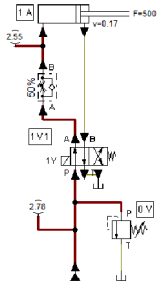
Description	Designation
Double acting cylinder	1A
4/2-way solenoid valve	1V1
Pushbutton (make)	S1
Make switch	K1



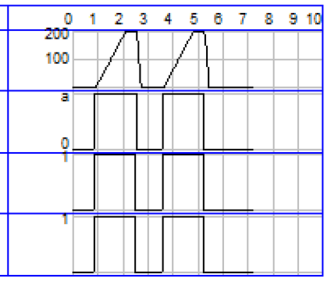
(b)Throttle valve opening 100%

Fig. 5. Simulation curve

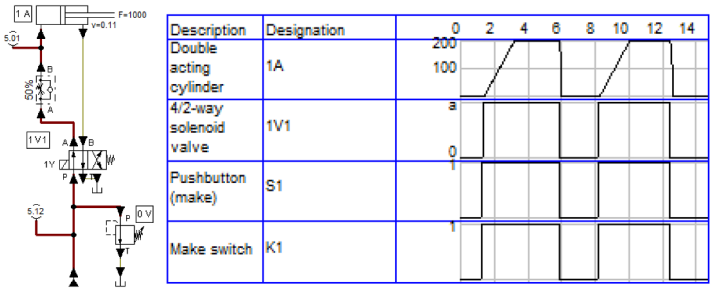
It can be concluded from Figure 5 that when the load is constant, different opening sizes have different times for the extension of the hydraulic cylinder. Figure 5 (a) shows that when the throttle valve opening is 50%, the time required for the hydraulic cylinder to fully extend is about 2.8s, and the movement speed is 0.11m/s; Figure 5 (b) shows that when the throttle valve opening is 100%, the time required for the hydraulic cylinder to fully extend is about 2.3s, and the movement speed is 0.13m/s. Therefore, it can be concluded that the flow of the throttle valve determines the inlet and outlet flow of the hydraulic cylinder. When the throttle valve opening increases, the speed of the hydraulic cylinder increases; on the contrary, when the throttle valve opening is zero, there is no flow in the hydraulic cylinder and the operating speed is zero. When the load remains unchanged, the speed of the hydraulic cylinder will gradually increase with the increase of the throttle valve opening.



Description	Designation
Double acting cylinder	1A
4/2-way solenoid valve	1V1
Pushbutton (make)	S1
Make switch	K1



(a) F=500N



(b) F=1000N

Fig. 6. Load changes

The hydraulic cylinder load is set to change. When the throttle is 50%, the simulation curve is shown in Figure 6. It can be seen from the simulation curve that when the external load is 500N, the hydraulic system pressure is 2.55MPa, the time taken to extend is about 2.1s, and the hydraulic cylinder movement speed is 0.17m/s; when the external load is 1000N, the hydraulic system pressure is 5.01MPa, the time taken for the hydraulic cylinder to extend is about 3.1s, and the hydraulic cylinder movement speed is 0.11m/s. Therefore, it can be concluded that the pressure of the hydraulic system depends on the external load. The greater the load, the higher the pressure. Conversely, the smaller the load, the lower the pressure. The movement speed of the hydraulic cylinder also decreases with the increase of the external load.

3 Conclusion

In the course of "Hydraulic and Pneumatic Transmission", the application of FluidSIM simulation software not only solves the problem of insufficient experimental conditions, but also allows students to build circuits through simulation and operation. In addition, students can perform simulation operations before actual experiments, which not only improves the success rate of the experiment, but also enhances the safety of the experiment. By using FluidSIM, students can better master the theoretical basis and engineering practice ability, deeply understand the principle of the circuit, and stimulate their interest in learning. At the same time, this method can also reduce errors in experiments and avoid potential dangers caused by wiring errors. Using FluidSIM simulation software, students can combine hydraulic and electrical knowledge to design circuits by themselves, improve students' innovative design ability and comprehensive practical ability, and teachers can also improve teaching efficiency and provide support for scientific research through this method.

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