Synchronization Control Simulation for Pneumatic Elevator Based on AMESim

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Abstract

For the research of simulation of synchronization control for pneumatic elevator, a model is builtin AMESim software. The simulations are used to research the impact of synchronous control strategy. The simulation results show that there are good synchronizing effects by applying pneumatic proportional technology and synchronization control with master-slave mode based on PID control. Some theoretical guidance is provided for synchronization control of real system.

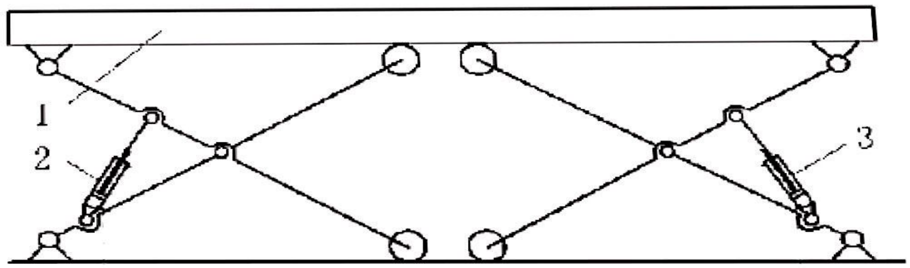
Index Terms: pneumatic elevator, synchronization control, PID control, simulation

I. Introduction and Problem Statement

The research of pneumatic synchronization control has an important position in pneumatic technology. The synchronization control system generally has multiple actuators, making them keep position synchronization at runtime. Actually, synchronization control is a special case of speed control. However, due to the compressibility of the gas, it is invalid to only control the gas flow in cylinder. It is hard to achieve the synchronization of two cylinders when the load of cylinder changes. In order to achieve the synchronization, mechanical connections are usually adopted to force synchronous running on every cylinder. This method is widely applied because of low cost. However, the systems of rigid connection of two cylinders appear stuck phenomenon, which affects the normal operation. The reasons for the phenomenon are asymmetry of gas path and the uncertainty of resistance of each cylinder. Therefore, this article adopts synchronous control strategy to ensure the synchronization. Simulation analysis of synchronization control for pneumatic elevator is carried out using AMESim software. The simulation results can provide the references for pneumatic elevator.

II. Problem Analysis

The functional diagram of pneumatic elevator is shown in Figure 1.The cylinder on both sides of hoisting device is completely independent. In the past, the dynamic characteristics of both sides of hoisting device are simply considered to be consistent, regardless of the effect on the performance of synchronization in the process of lifting. So it is easy to cause the lifting system is unsynchronized and appears even stuck phenomenon, which affects the normal operation.



1-working table 2- cylinder on the left side 3- cylinder on the right side

Fig.1: Functional Diagram of Pneumatic Elevator

There are many reasons for position asynchronies of cylinders on both sides. The followings are the main reasons:

1) When the platform is under offset load condition, two cylinders have different load. Due to the compressibility of the gas, the cylinder which sustains heavier load runs slower.
2) The friction of cylinder is different, because of error of manufacturing accuracy of cylinders or the difference of matching gap of kinematic pair. The high friction cylinder runs relatively slower.

III. Simulation Analysis

For convenience of narrative, this article assumes the cylinder on the left side as 1# cylinder and the cylinder on the right side as 2# cylinder. To simulate the actual process of lifting, the load and friction of two cylinders are different. The main parameters of two cylinders areas shown in Table.1 and Table.2.

Table.1: Main Parameters of 1# Cylinder

Title	Value	Unit
cylinder diameter	50	mm
length of stroke	0.4	m
viscous friction coefficient	510	N/(m/s)
total mass being moved	11	Kg

Table.2: Main Parameters of 2# Cylinder

Title	Value	Unit
cylinder diameter	50	mm
length of stroke	0.4	m
viscous friction coefficient	500	N/(m/s)
total mass being moved	7	Kg

A. Simulation Model without Synchronous Control Strategy

A simulation model without synchronous control strategy is shown in Figure 2.

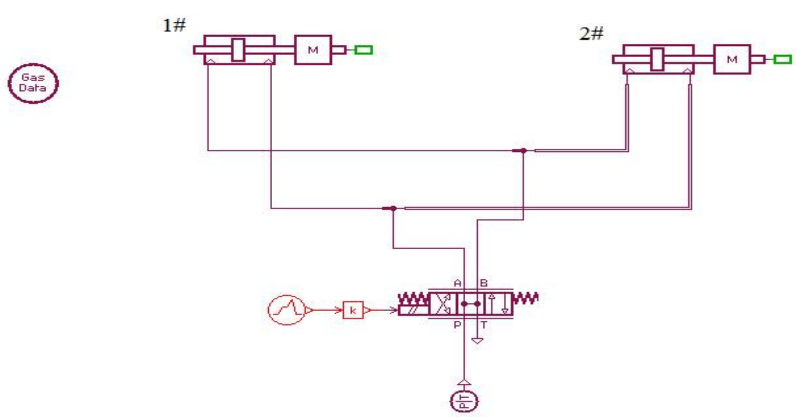


Fig. 2: Simulation Model without Synchronous Control Strategy

Displacement curves of two cylinders are shown in Figure 3.As indicated in Fig.3, the speed of the two cylinders is different. The 1# cylinder is slower, which has higher load and larger viscous friction coefficient.

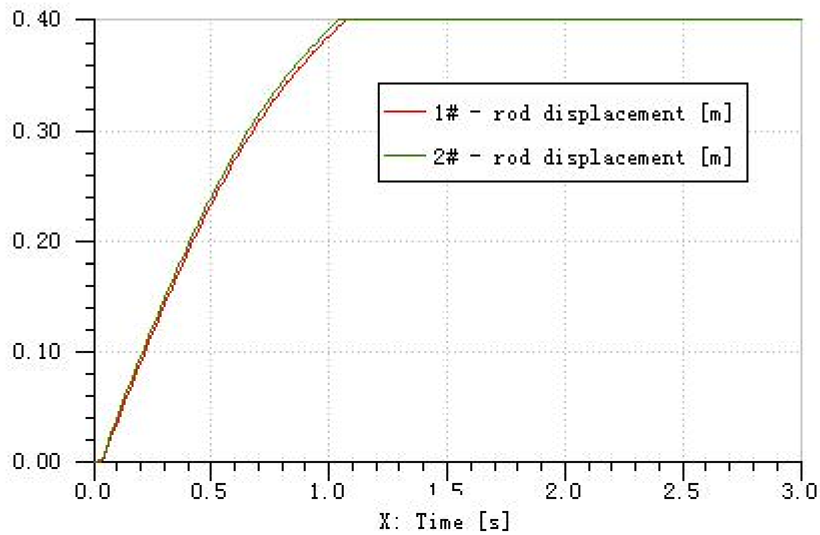


Fig. 3: Displacement Curves of Two Cylinders

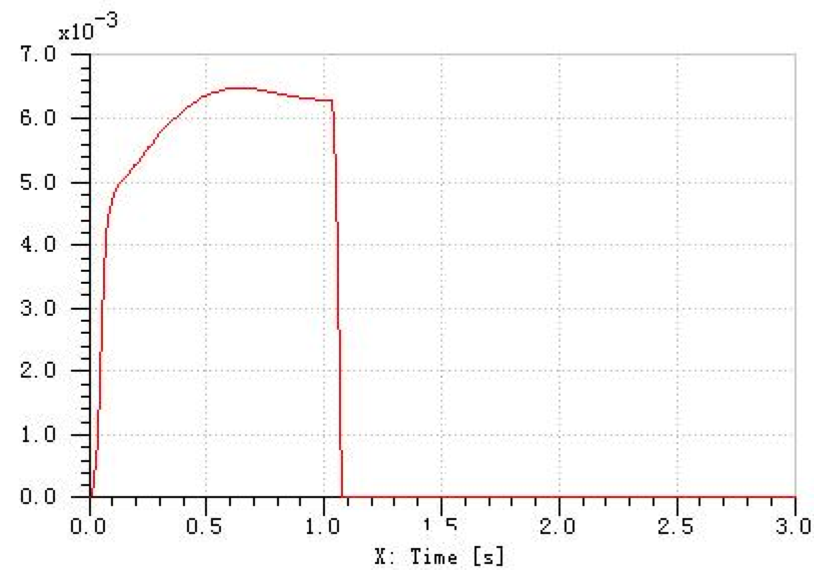


Fig. 4: Displacement Difference Curve of Two Cylinders

Displacement difference curve of two cylindersis shown in Figure 4. With the cumulative time, the displacement difference of two cylinders is rising, because the speed of 1# cylinder is slower than 2# cylinder's. As indicated in Fig.4, when it is 0.6s, the max displacement difference of the two cylinders reaches 6.4 mm. By this conversion, there will be about 10 mm error per second. It's very easy to cause position asynchronies, which may make the platform tilt or appear stuck phenomenon. Therefore, it is necessary to adopt synchronous control strategy.

B. Simulation Model with Synchronous Control Strategy

There are two kinds of synchronization control method commonly used. One method is open loop control. This method has the advantages of simple principle and low cost. But the control precision is low. Another is closed loop control. It could meet the requirement of high precision synchronous control. Master-slave mode is a common control strategy and control method. It is used in this article. The control scheme is shown in Figure 5.In the article, 1# cylinder is seen as master cylinder, and 2# cylinder is seen as slave cylinder. The displacement of 1# cylinder is defined as ideal output. 2# cylinder is controlled to track the ideal output and achieve synchronization.

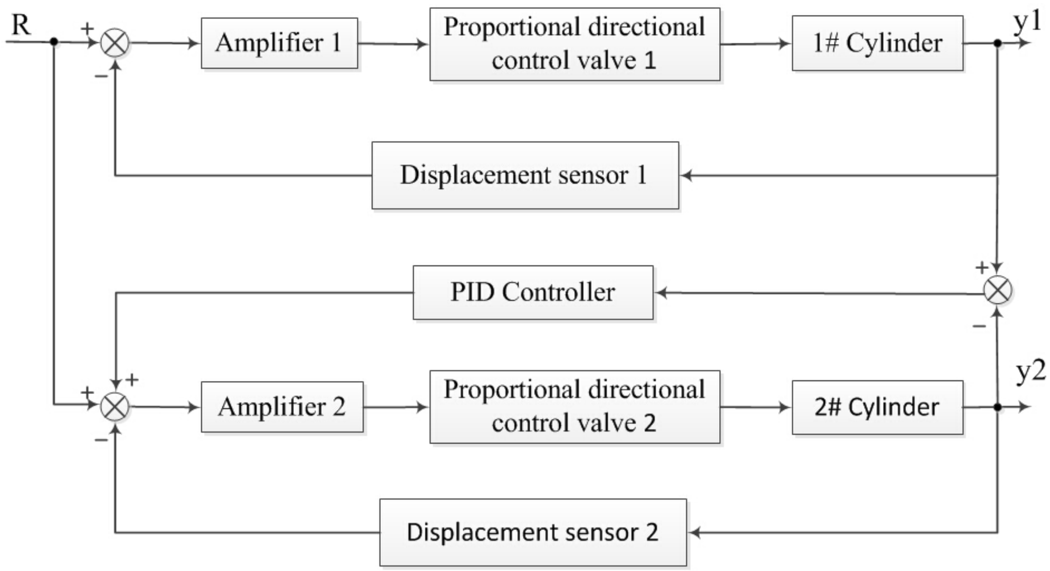


Fig. 5: Control Scheme

Asimulation model with synchronization control is set upin AMESim software, as shown in Fig.6. Parameters of the system are as same as the system without taking synchronization control. Because of the difference of the load and friction, the speed and displacement of the two cylinders are different in the process of working. At this point, according to the displacement difference, the synchronization controller generates a compensation signal. In order to achieve synchronization, the output of the signal is applied to the proportional directional control valve 2 and used to drive2# cylinder. The parameters of PID controller ($K_p = 180, K_i = 300, K_d = 10$) are determined by relevant experience and cut and try methods.

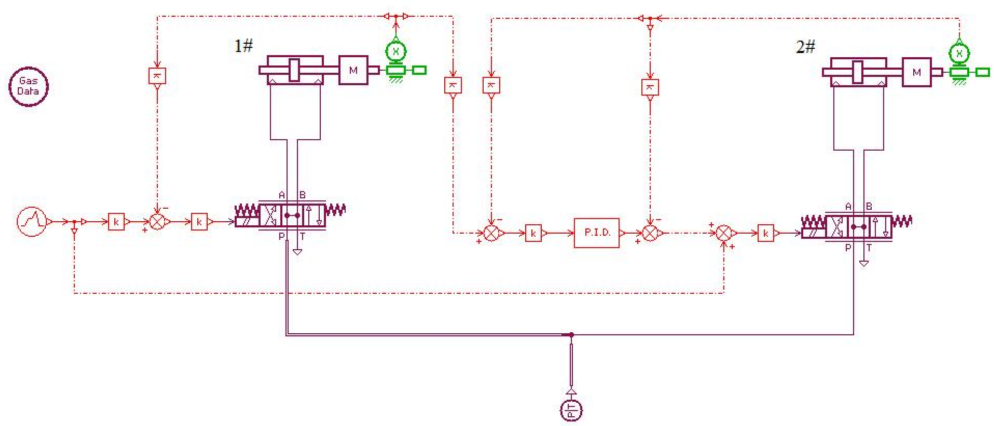


Fig.6: Simulation Model with Synchronization Control in AMESim Software

With the synchronization control,the displacement curves of the pistonsare indicated in Fig.7.As indicated in Fig.7, the system is stable.The cylinders run smoothly. The displacement curves of the cylinders coincide. Compared with Fig.3, the synchronization performance of the system has an obvious improvement.

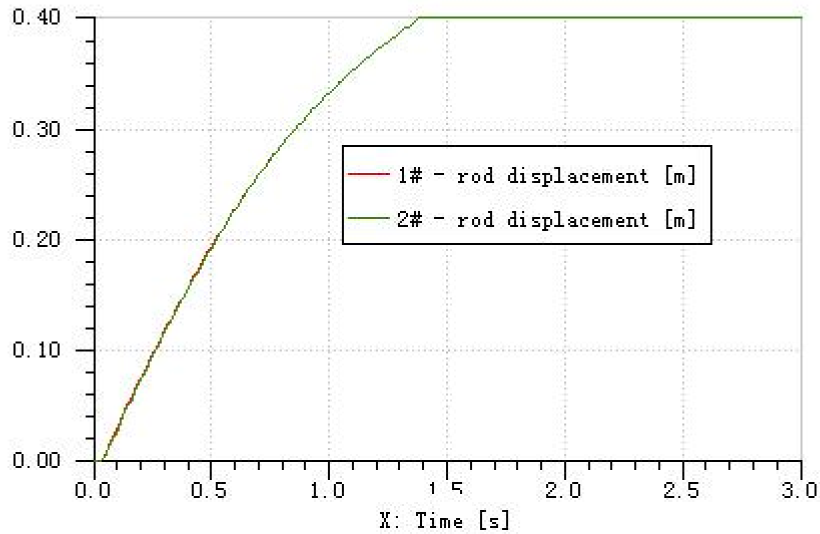


Fig.7: Displacement Curves of Pistons with Synchronization Control

With the synchronization control, the displacement difference curve is indicated in Fig.8.As indicated in Fig.7, when it is 0.1s, the max displacement difference of the two cylinders reaches 3.4 mm. As a result of the action of the synchronization controller, the displacement difference is reducing. After 1.4s, it becomes zero.

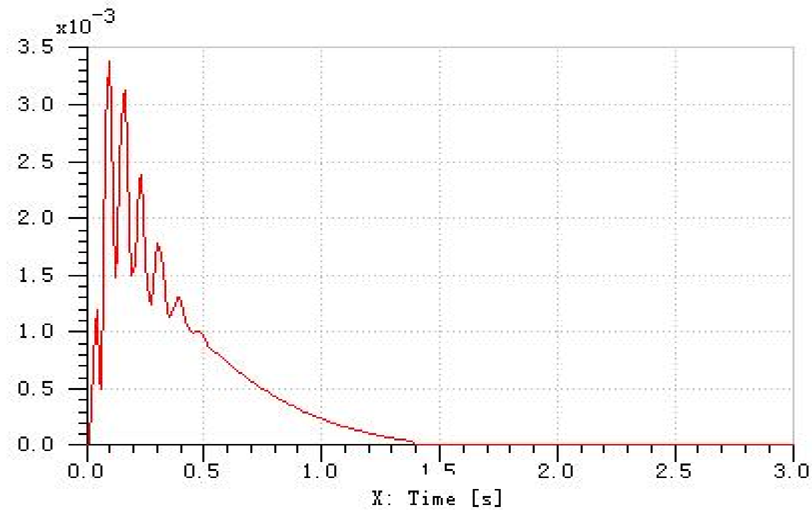


Fig.8: Displacement Difference Curve of Pistons with Synchronization Control

Comparing figure 4 and figure 8, it can be found that the running time of the system extends from 1.1s to 1.4s after the synchronous control strategy is used. Gratifyingly, its synchronization performance has been significantly improved, and the maximum displacement difference reduces from the original 6.4mm to 3.4mm.Even more momentously, with the synchronous control strategy, the displacement difference of two cylinders is reducing. Without the synchronous control strategy, the displacement difference has been accumulated. Therefore, the synchronization control strategy used in this article is effective.

IV. Conclusion

To research the synchronization performance and the effect of synchronous control strategy, simulation analysis of synchronizing thrust for pneumatic elevator is carried out using AMESim software. The simulation results show that there are good synchronizing effects by applying synchronization control with master-slave mode based on PID control. Some theoretical guidance is provided for synchronization control of real system.

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