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T. Szabó / A. Czmerk

Sliding Mode Control Model of a Nonlinear Pneumatic System

ABSTRACT

The pneumatic motion was used for the actuation only between the two ends of the stroke for a long time. The aimed positioning was realizable only in the letter decade by analog PID controller which widely used in the industry. This solution for the control of the pneumatic cylinder is limited useful because of the varying parameters, and big dead time. To achieve the wanted behavior of the pneumatic system, a modern control algorithm necessary. To search results of studies up to now, and build a simulation model which suitable to describe the real dynamic behavior of the cylinder are parts to realize this goal. By the investigation of existing nonlinearities in each component make possible the build of the simulation model, and make easier the tests of the various control strategies like sliding mode control.

This control algorithm is suitable because of his robustness to variations of system parameters, and external disturbances. The simulation results show that the implementation of this control is effective in servopneumatic systems, and in addition is appropriate for further practical implementations.

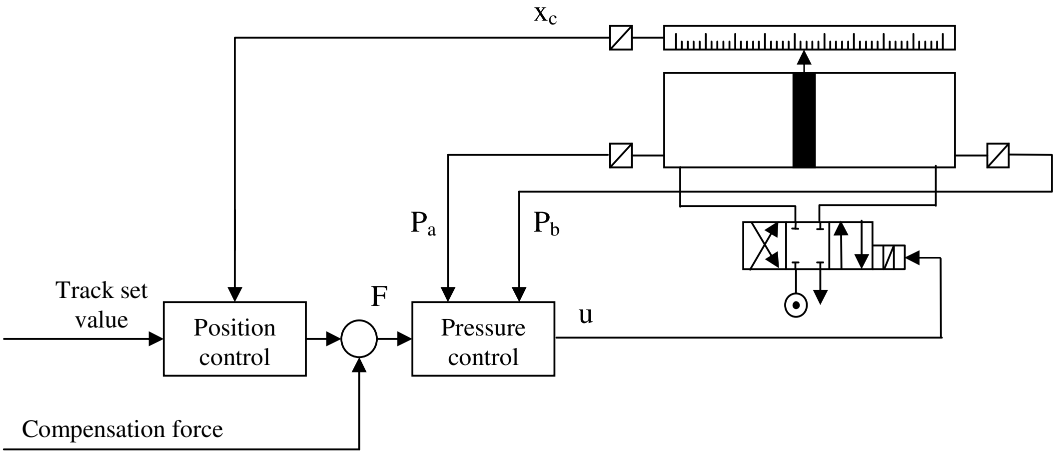

Fig.1. Structure of the decentral control of pneumatic system

INTRODUCTION

The pneumatic actuator is widespread used because of his dependence, long life, as well as his wet-strength operation and low price. It is advantageous, that compressed air is serving for the energy transfer in the most plants. Disadvantage is from their build-up resulted nonlinearities. The dynamic behavior of pneumatic cylinders is characterised by significant nonlinearities. In the paper used model based on the differential equations which are suitable to describe the dynamic behavior of the cylinder, and the servovalves also.

SLIDING MODE CONTROL DESIGN

The sliding mode control has been proposed as a robust control method, able to mach the high performance of a control system in the presence of variable operating conditions or system nonlinearities. The gains of the sliding mode controller are constant, but discontinuous, which are switched about the sliding surface.

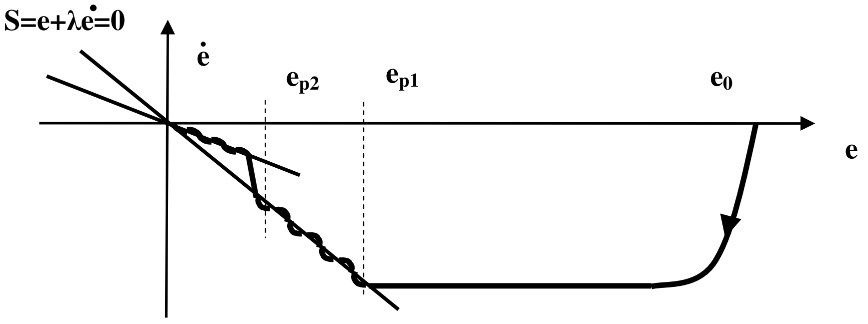

Fig. 2. Sliding motion in the state space using adaptive parameter varying

The servopneumatic drive can consider as a single input, single output (SISO) system, so the state space equation is:

$$\dot{x} = f(x,t) + b(x,t) \cdot u \tag{1}$$

Where x is the state vector and u is the input vector. The expression $f(x,t)$ is not exatly known function, and $b(x,t)$ is the gain of the control signal. The goal of the sliding mode control is to press the state vector into a desired state of the system, namely approach the sliding surface and then move along on it into the origin.

The tracking error e is the difference between the actual, and the reference position of x.

$$e = x_S - x_R \qquad (2)$$

The trajectory of the error vector has to define from approaching phase to sliding phase. So the sliding condition derived from the Ljapunov equation has to satisfy :

$$s(\dot{e}, e)\cdot \dot{s}(\dot{e}, e) < 0 \qquad (3)$$

The error goes toward the sliding surface. Generally the scalar variable can calculate next:

$$s = e + \lambda \cdot \dot{e} \qquad (4)$$

where λ can explain as a slope of the sliding surface in the phase plane

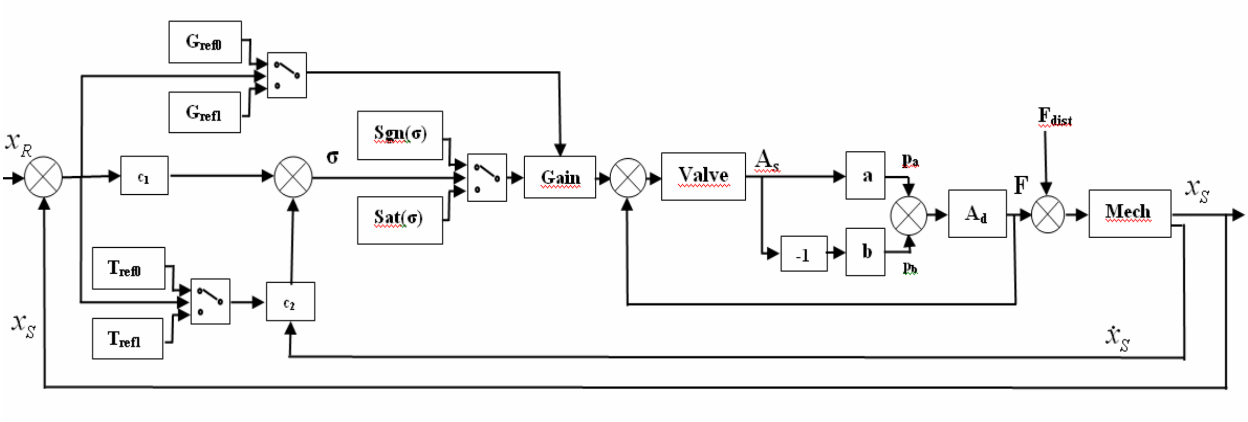

Fig. 3. Block diagram of the pneumatic servo position control

RESULTS

The simulation results shows, that the positioning of the pneumatic servo system can reach the micrometer range in the face of using frictional movement.

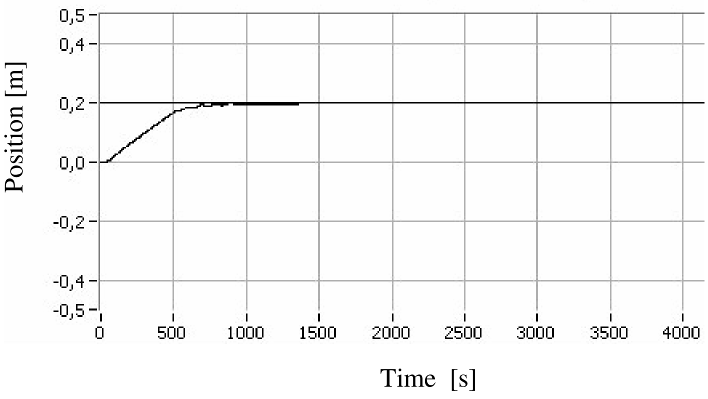

Fig. 4. Positioning with sliding mode controller

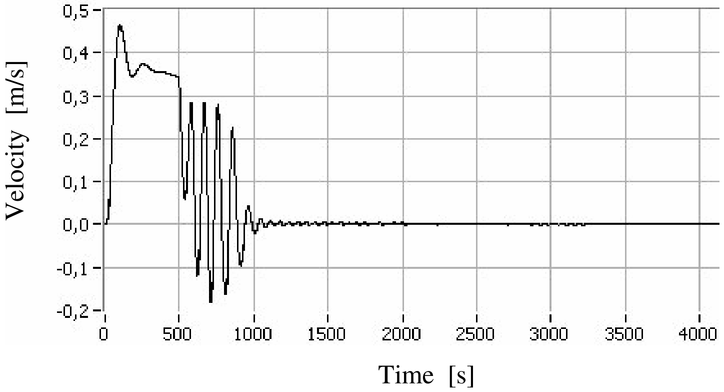

Fig. 5. Velocity of the piston during positioning

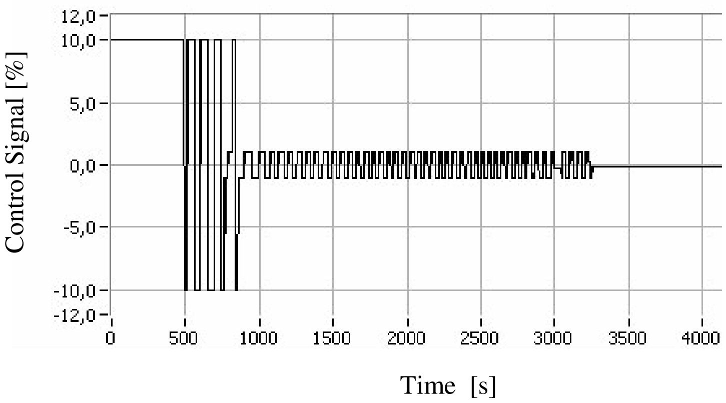

Fig. 6. Control signal of the valves during positioning

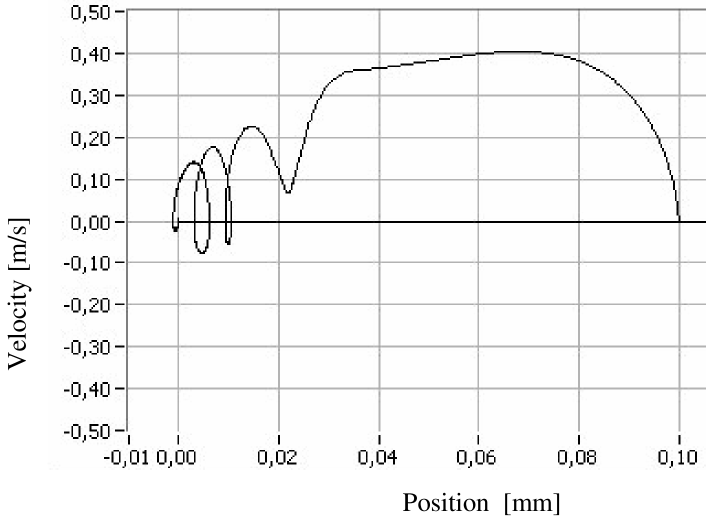

Fig. 4. Phase-plane tajectory during positioning

CONCLUSION

The dynamic behavior of pneumatic cylinders is characterised by significant nonlinearities. In the paper used model based on the differential equations which are suitable to describe the dynamic behavior of the cylinder, and the servovalves also. The simulations have shown that sliding mode control is able to maintain the requirements of the control system with an appropriate accuracy.

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