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Methods of controlling a hybrid positioning system using LabVIEW

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Abstract

The paper presents the design of positioning unit acting in a different way with respect to the known methods of controlling the positioning devices. The prototype positioning unit consists of a double-acting cylinder and electromagnetic brake. The proposed hybrid positioning unit allows to free programming of the displacement of the actuator. In the illustrated solution significant disadvantages which often occur in the positioning pneumatic drives were eliminated. The proposed hybrid positioning system provides to maintain the desired position, shorter positioning times, a higher average speed of the piston and a higher positioning accuracy. The fulfilment of such parameters provide a construction of accordingly developed unit which consist of pneumatic drive and control system. Element of control system is the measuring card NI PCI-6221 for data acquisition and control system positioning. LabVIEW allow to control the object, carrying out the visualization of the process control and analysis of measurement data.

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1. Introduction

The paper presents a new method of positioning hybrid pneumatic system equipped with an electromagnetic brake. Pneumatic drives are used in various areas of technology, mainly for driving machines, industrial robots, manipulators, handling equipment and machine tools [1]. However, their application in multi-axis parallel and Cartesian manipulators is limited due to insufficient positioning accuracy. The problem encountered in the case of electro-pneumatic servo systems is their unstable operation [2]. They are prone to both external and intrinsic interferences [3]. "The cause of problems with positioning accuracy encountered in the case of pneumatic servo drives is the complex, non-linear process in which the compressed air energy is converted to the driving power used to move the cylinder piston. Due to insufficient and incomplete knowledge this problem poses a major challenge and it is particularly important in the case of controlling the position of pneumatic servo systems" [4]. Feedback loops and controllers can be used to improve accuracy of positioning and to eliminate interferences [5, 6]. The source of control input signals is a linear displacement transducer which records non-measurable variables of the piston status,

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namely speed and acceleration by differentiating and integrating the control signal.

2. Prototype of the proposed hybrid pneumatic system

The prototype described in this paper has been designed and built to address the need for improvement of the existing pneumatic positioning systems. The proposed system comprises of a double-acting piston rod cylinder and an electromagnetic brake assembly. This system is innovative in that it allows for free programming of the output device displacements. This operational feature requires efficient controlling the process of filling the cylinder chambers and operating the electro-magnetic brake. The optimum performance of these processes is ensured by controllers. The prerequisite for choosing optimum controller type and settings is the information on the dynamic properties of the controlled object. Hence, investigation of the object to derive its dynamic model should be considered an important part of the control system design. Then it is necessary to formulate the control quality requirements (transient state response and steady state curves) [7, 8, 9]. Based on this information the controller structure and settings are derived. The control is based on comparing the output signal from the controlled object with the setpoint and the obtained difference is used as the input to modify the control signal. Modifying the control signal on the basis of the difference between the setpoint and the output signal from the object requires implementation of feedback loop system [10, 11]. Based on the testing of the hybrid positioning system PID controller appears to be the optimum choice for controlling the electro-magnetic brake and, with state space control of the proportional valve, it ensures the best positioning accuracy. The PID controller board enables automatic closed-loop control. The controller maintains the value pre-set by the user by using the proportional, integral and differential terms. The PID algorithm is described by the following equation:

$$u(t) = k\cdot(e(t) + 1/T_i\cdot\int e(t) + T_d\cdot e(t)/dt), \tag{1}$$

where, u(t) is control signal, k is proportional gain, T_i is integral time, T_d is derivative time, e(t) is control error calculated as follows:

$$e(t) = w(t) - y(t). \tag{2}$$

The transfer function of PID controller is:

$$U(s)/E(s) = k_r(1 + 1/sT_i + sT_d). \tag{3}$$

Block diagram of PID controller based system is represented in Figure 1 below.

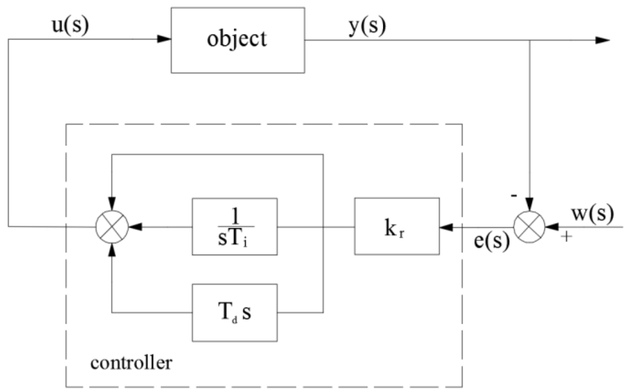

Fig. 1. Block diagram of PID controller based system