Hydraulic positioning actuators with magnetorheology control

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Introduction

There are lot of various engineering application of magnetorheology (MR) fluids in smart systems such as semi-active dampers, fluid clutches etc [1]. Moreover the high yield stress of magnetorheology (MR) fluids allows to using it in high power hydraulic positioning actuators as a hydraulic fluid, which is pressured into valves system by means of conventional pump. In this work the designs and investigations of performances of such actuators with MR control are presented.

Essential principles

The typical valves system in these actuators is based on Wheatstone bridge hydraulic power circuit. The principle of the operation is follows: the fluid is pumped from the pump to the hydrocylinders through the input MR-valves and then pumped out through output MR-valves. The positioning object will be moving because of pressure difference in opposite hydrocylinders. Control of pressure difference is carried out due to adjustment of yield stress of MR fluid in MR valves. MR-valve is one of the basic elements of actuator and it is consist of a core, body and an annulus through which the MR fluid flows. A current applied through the wire coil creates a magnetic field in the working gap of the valve. The magnetic field increases the yield stress of the MR fluid and so raises the pressure difference in the gap.
The scheme of one-coordinate MR actuator with high range of moving (200 mm) is presented at fig. 1.

Advantages and problems

One of the most important advantages of using MR control in hydraulic actuators is that, there is a possibility to not use a kinematical pairs of external friction in a design and it is allows to have a high precision and smoothness of moving. The magnetic control also allows having high dynamic parameters as there are no mobile inertial elements in valve system. Nevertheless, there are some problems, such as hysteresis, which can come to minimum by means of closed loop control. Another problem is the MR fluids destabilization.

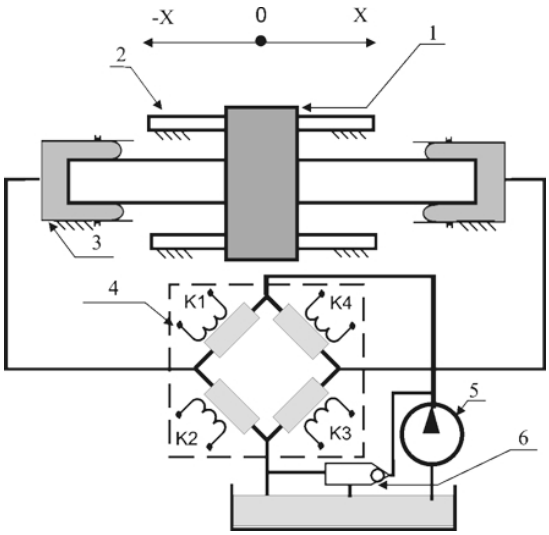

Figure 1: Scheme of one-coordinate MR actuator: 1 – positioning object, 2 – guides, 3 – hydrocylinders, 4 – valves system, 5 – pump, 6 – overflow valve.

Basic performances and applications

The basic performances of developed actuators are following: time of response no more than 200 msec; an error of positioning on linear coordinate X,Y,Z less than 1 mic; length of travel on linear coordinates up to 200 mm. The load capacity of MR actuators can be more than 1000 N. Also there is a possibility to use such actuators in vacuum systems [2].
Above mentioned characteristics enable the MR actuators using for precise positioning applications e.g. for the positioning of pri-

mary mirror elements of extra-large ground based astronomical telescope. The scheme of three-coordinate MR actuator for the mirror positioning is presented at fig. 2.

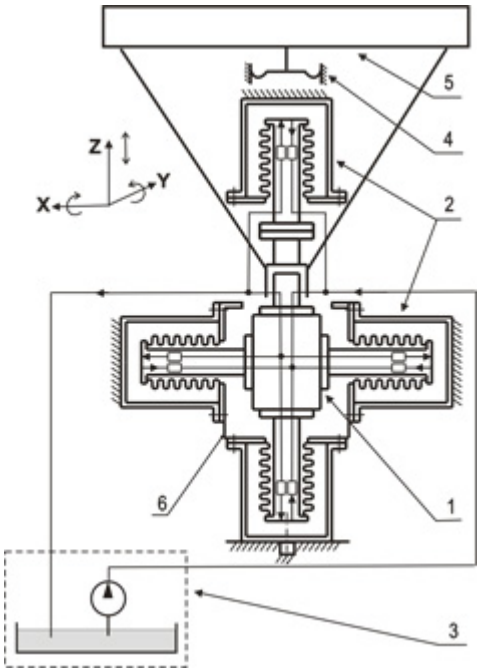

Figure 2: The scheme of three-coordinate MR actuator: 1 – mobile body; 2 – hydrocylinders (in- and output MR valves inside; the pair of hydrocylinders for the Y-coordinate not shown); 3 – pump; 4 - guides; 5 –positioning object (mirror).

References

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[2] Deulin E.A., Mikhailov V.P., Sytchev V.V., Borin D.Y., Variable rheology usage for precise drive// Proc. Of 4th International Symposium "Vacuum technology and equipment": Charkov, Ukraine, 2001. – pp.163-166.