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Study of an electro-hydraulic servo actuator flexibly connected to a boom manipulator mounted on a jaw crusher

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Abstract: The study deals with the electro-hydraulic servo actuator (EHSA) for position control of the boom manipulator mounted on the jaw crusher. The manipulator is used to move a hydraulic rock hammer. The SHD is rigidly connected to the main boom and flexibly connected to the inner boom via a spring damping device (SDD). The nonlinear dynamic model of a dynamic system with 2 degrees of freedom (DoF) has been presented. In the Simscape Fluid simulation tests, the dynamic responses of the dynamic system to cyclical excitations generated by the rock breaker were analysed. Based on the dynamic responses, the dynamic properties of EHSA rigidly and flexibly connected to the load mass excited by a constant force or a cyclic force generated by a rock breaker were compared. The EHSA dynamic system based on the Hammerstein model using the third-order polynomial function for the nonlinear static subsystem and the ARX model for the dynamic linear subsystem was identified.

Keywords: electro-hydraulic servo actuator, crusher manipulator, flexible connection

1. Introduction

The mechanical vibrations from the rock breaker to the crusher manipulator and the hydraulic system components are transmitted. The contributes significantly to trouble with the operation and maintenance of hydraulic components and systems. The designer of the crusher manipulator and the hydraulic system should foresee operational problems related to long-term mechanical vibrations. However, the most common practice is simple design solutions that provide short-term operational benefits.

2. Results and Discussion

The use of EHSA has been considered, in which the cylinder is rigidly mounted to the main boom and the piston rod is flexibly connected via an SDD to the inner boom of a hydraulic crusher manipulator. The simulation results to select the SDD and the vibration exciter on the test stand were used. A spring with viscous damping devices enables effective damping of vibrations at high dynamic loads, such as a hydraulic rock breaker. The EHAS used consists of a differential hydraulic actuator, a 4/3 proportional directional control valve with electrical position feedback, and integrated control electronics (ICE) so-called On-Board electronics (OBE). The purpose of the simulation tests is to assess the dynamic properties of an EHSA rigidly and flexibly connected to a load mass excited by a cyclic force. The step response of an EHSA rigidly and flexibly connected to a load mass at constant force or cyclic force generated by the rock breaker was compared. The experimental test aims to select such a control system for the EHSA flexibly connected to the mass of the load, which will ensure the accurate extension of the internal telescopic boom at the cyclic excitation force (impact force).

Fig. 1 shows the model of a jaw crusher with a rock conveyor and a mounted boom manipulator.

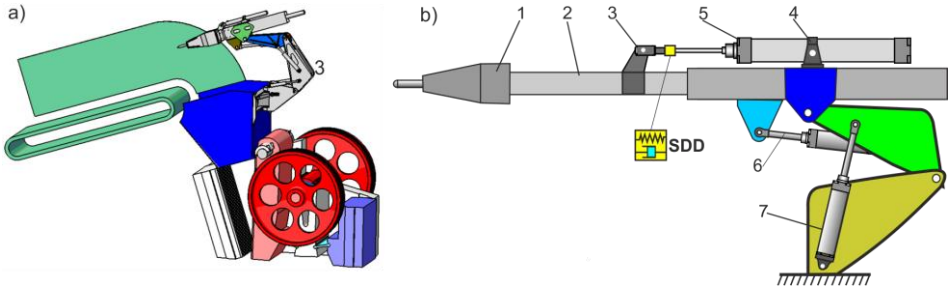

Fig. 1. The boom manipulator mounted on a jaw crusher a) model of a jaw crusher, b) model of a boom manipulator: 1 – hydraulic rock breaker, 2 – telescopic boom, 3 – clevis bracket, 4 – center trunnion, 5 – inner boom cylinder, 6 – rotation cylinder, 7 – lifting cylinder, SDD – spring damping device

Fig. 2 compares the step response of an EHSA rigidly and flexibly connected to a payload mass at constant force or cyclic force generated by the rock breaker.

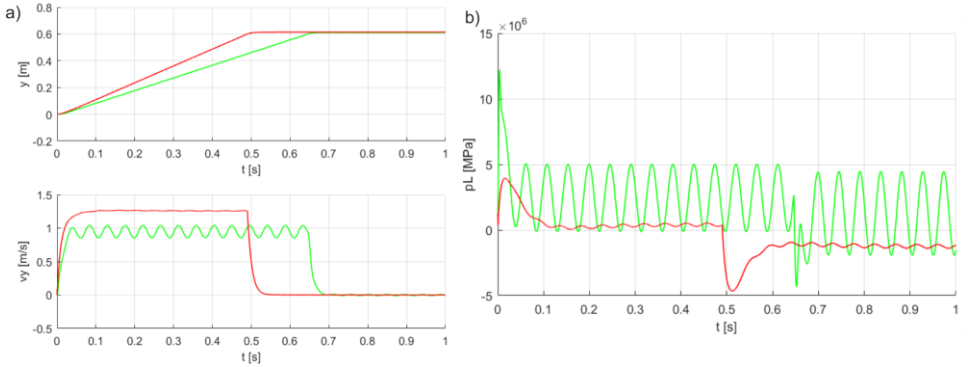

Fig. 2. Comparison of dynamic responses of the displacement $y(t)$, the speed $v_y(t)$ (a), and load pressure $p_L(t)$ (b) of an EHSA rigidly (green line) and flexibly (red line) connected to a payload mass m_L = 250kg, for y_{set} = 0.6m and excitation force $F(t)$ at frequency f_e = 21.8Hz

The comparison of the EHSA step response shows a difference in the SHD dynamic properties for a rigid and flexible connection with a load mass at constant force or cyclic force, generated by the rock breaker.

3. Concluding Remarks

The paper analyses the difficult and complex problem of EHSA control flexibly connected to the load mass excited by the cyclic force generated by a rock breaker mounted on the boom of a jaw crusher manipulator. The EHSA control system on the test stand has been verified. This test stand will be used to carry out research projects of EHSA-SDD systems for constructors of hydraulic manipulators of crushers, users of jaw crushers, and producers of aggregates for the cement industry. Simulation and experimental studies of the EHSA-SDD system are of great importance in the design and operation of heavy hydraulic manipulators with large moving masses and mechanical structures susceptible to elastic deformation. These manipulators are used in construction mining machines.