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CONTROL AND STUDY OF HYDRAULIC SYSTEM USING PLC AND CONSTRUCTION/VERIFICATION OF THE MATHEMATICAL MODEL OF THE CONTROLLED SYSTEM

1. Introduction

The work described below has been carried out at the stand made in the Institute of Heavy Machinery Engineering of the Warsaw University of Technology. Basic elements of the hydraulic stand are: a variable displacement pump, a proportional directional valve and a proportional pressure valve. The above elements are controlled electronically. Besides, the stand includes two hydraulic cylinders operating in backward configuration and pressure sensors (pressure before the proportional directional valve, before the hydraulic cylinders and before the proportional pressure valve is measured), flow (after the pump) and stroke (of the piston). The control system includes PLC SMART I/O made by PEP Modular Computers and PC communicating with the controller via RS232 link. PC serves as a device recording the results of measurements and as a processing device.

2. Scope of Work

The work in question was aimed at constructing a regulator of the piston stroke in the hydraulic cylinder, studying its operation under different values of load and its modification, to reduce energy loss generated when choking oil flow through the proportional directional valve. At the end of this stage, PLC usability for studying and controlling hydraulic elements was assessed. Moreover, building a mathematical model of the system has been started.

3. Structure of Control System

With reference to the above-mentioned stand, the purpose of the control system is to generate a signal controlling the proportional directional valve, depending on the existing control deviation. The control deviation is the result of the difference between real piston stroke and preset piston stroke. Opening the directional valve results in the piston movement towards preset position. The diagram of the control system of the stand is shown in Fig. 1.

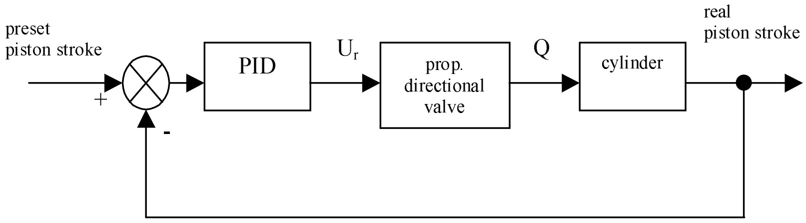

Fig. 1. The diagram of the control system

First, basing on the study, the regulator parameters were found. After they have been applied, it turned out that the regulator did not work properly. So, a multiregulator was built which changes proportional gain, depending on the flow reaching the directional valve. Moving piston was then subjected to load, similar to that applied to a hydraulic cylinder of an excavator bucket during excavation process. The task of the control system was to achieve the preset stroke of the hydraulic cylinder within preset time, as well as to react to the excessive force acting on the cylinder. An important difficulty in the regulator operation was strong interference of the measurement signal from the piston stroke sensor. Influence of this interference was minimised with the aid of appropriate software. The control program has been equipped with a procedure filtering the signal in question.

Next step was the modification of the control system. It consisted in introducing to the program procedures controlling pump flow. The diagram of the control system after modification is shown in Fig. 2.

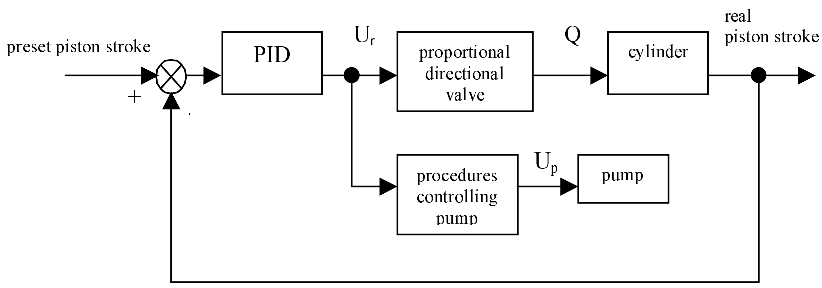

Fig. 2. The diagram of the control system after modification

After applying the modification, comparative characteristics of the power demand and time to reach the preset position for two control systems (before and after modification) were made. The applied changes brought about substantial reduction of the energy loss resulting from choking flow during closing of the proportional directional valve for small stroke speed and short strokes. For large speed and long strokes, the reduction of energy loss was insignificant, because the time to reach the preset position got longer. The modification anticipated significant reduction of the pump flow. Further work associated with limiting energy loss during braking should assume continuous change of flow.

4. Evaluation of Usability of PLC Controller

Main criteria applied when evaluating PLC are maintaining working parameters specified by the manufacturer in the technical documentation and the quality of the utility software. An important element is also the possibility of communicating with other devices, e.g. a PC.

5. Construction of Mathematical Model of the Stand

To construct the mathematical model, a simulation program VisSim, made by Visual Solutions, was applied. This program operates in Windows environment. In the VisSim program, the model of the system is defined using a block diagram. It includes the library of blocks, representing various arithmetical functions, logical functions, integral calculus, as well as optimisation and animation methods. Mathematical description of the system includes not only hydraulic elements but also the part of program controlling the stand. This is associated with the plan to subject the model to the same study that was applied in the real stand. A system for piston stroke control was described and it is possible to introduce variable load into hydraulic cylinder system.