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AUTOMATED HYDRAULIC DEVICE FOR CEC PROCESS ENGINEERING

AUTOMATIZOVANÉ HYDRAULICKÉ ZAŘÍZENÍ PRO TECHNOLOGIÍ CEC

Abstract

The paper presents a prototype automated hydraulic device for cyclic extrusion compression (CEC) process engineering. Presented device is a horizontal double hydraulic press equipped with electrohydraulic control system, designed using proportional technique and microprocessor control. A first part of this paper presents a structure and a working scheme of the device. A second part describes implemented device's measurement and control circuit. Sample characteristics from extrusion process, recorded during press work, are presented in final part.

Abstrakt

Příspěvek popisuje prototyp automatizovaného hydraulického zařízení pro řízení cyklické průtlačné komprese. Prezentované zařízení je horizontální dvojitý hydraulický lis vybavený elektrohydraulickým řídícím systémem navrženým tak, aby využíval proporcionální technologii a řízení mikroprocesorem. V první části příspěvku je popisována konstrukce a pracovní proces zařízení. V druhé části je pak zmíněna implementace řídícího a měřícího obvodu. V závěrečné části jsou uvedeny ukázky veličin zaznamenané během lisování.

1 INTRODUCTION

Cyclic extrusion compression (CEC) belongs to unconventional methods of forming metals, alloys, and powder materials, with plastic strains as large, as needed. This kind of strain conditions allows a production of nanocrystalline materials [RICHERT 1995]. Presented device operates according to a method developed in Faculty of Non-Ferrous Metals, AGH University of Science and Technology in Krakow, and protected by Polish patent. Patented method of straining materials is one of the best methods worldwide for volumetric strain. The device allows plastic straining even for materials that are difficult to strain. This allows a production of nanocrystalline materials, which, due to a very small grain, react to external stimuli (e.g. light, electric, or mechanical stress) in a different manner than micron-sized grains. Importance of this kind of materials will increase in material technologies. Their implementation rate will be determined by finding the most advantageous method for their production. One of the aims of developed device is to make attaining this goal possible.

2 THE DESIGN AND OPERATING PRINCIPLES OF THE DEVICE

Presented device (figure 1) consists of the following main units: a mechanical construction, a set of two horizontal hydraulic presses working in opposite directions, a hydraulic unit, a tool unit, a measurement and control circuit, and an electric power supply unit. In figure 3, the device functional diagram, limited to most important elements, is presented. Hydraulic presses are working unit of the device. Their main elements are doubled cylinders of special construction (figure 2). Pistons 3.11,

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3.21 of cylinders 3A1, 3A2 are designed for clamping and locking tool unit. Pistons 1.1, 2.1 of cylinders 1A1, 2A1 are used for carrying out manufacturing process. With all cylinders cooperates a hydraulic unit (figure 1), that has electrohydraulic control system, cabinet with electric power supply and protection elements, and electronics of measurement and control circuit installed inside it.

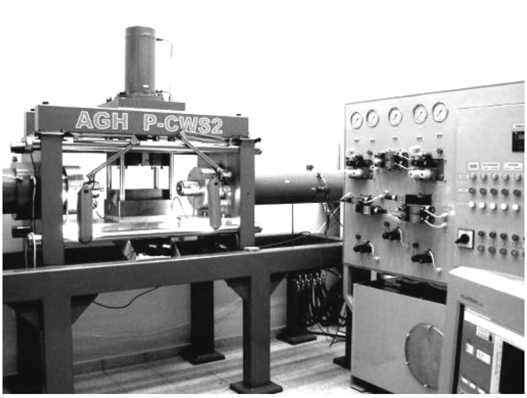

Fig. 1 View of the device

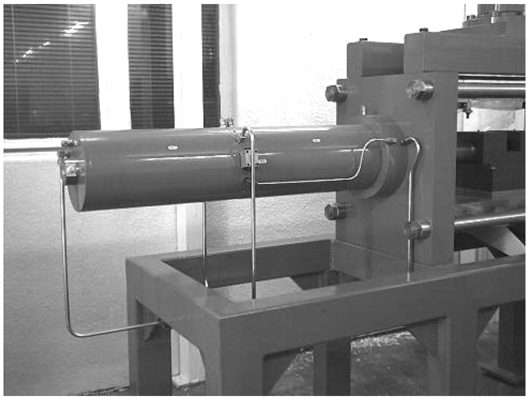

Fig. 2 View of the cylinder

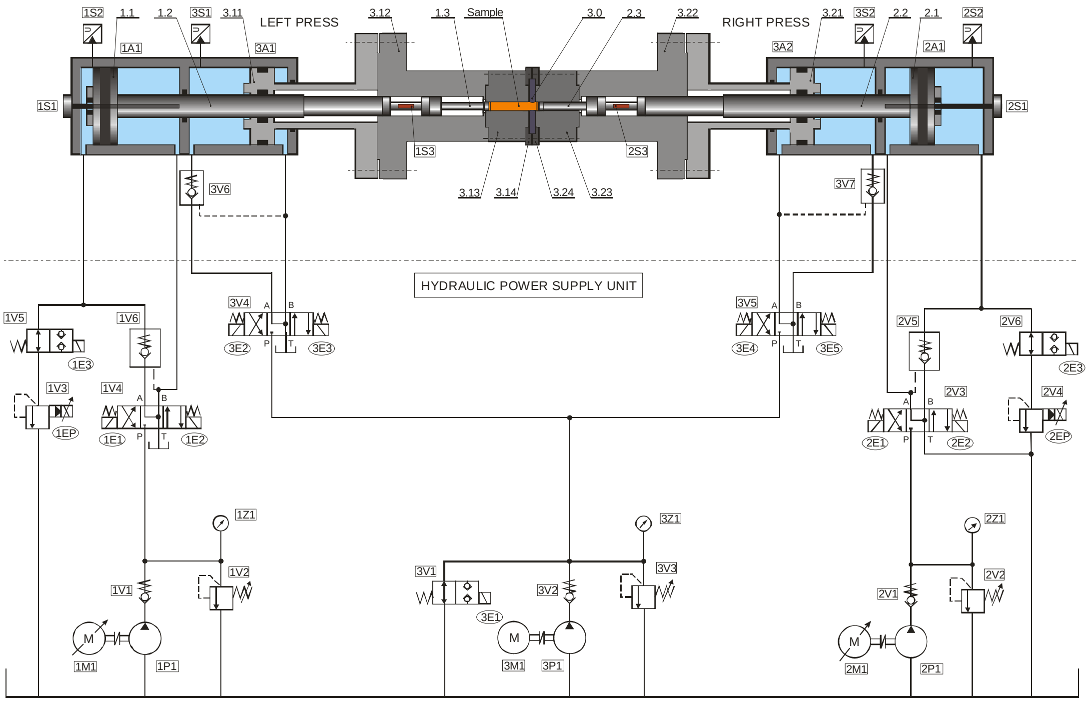

Fig. 3 Simplified diagram of the electrohydraulic system

Tool unit consists of the following main elements: extrusion rams 1.3, 2.3, extruders containters 3.13, 3.23, retaining rings 3.14, 3.23, and extrusion die 3.0. In short, process of extrusion compression consists in redrawing a material sample, formed as a round bar, through properly shaped extrusion die aperture. Diameter of this aperture must be, of course, smaller than sample diameter. Pistons 1.1, 2.1, and piston rods 1.2, 2.2, pushing extrusion rams, are designed for extruding sample. Force sensors 1S3, 2S3 are located between rods and extrusion rams. Sample is being extruded repeatedly to the left, and to the right. During operation, one ram extrudes the sample with fixed velocity, while the second one works in the opposite direction with strictly defined cushioning force. In utmost positions sample compression must be also retained by forces with value equal to cushioning force. After change of movement direction, an exchange of rams functions follows. Now, the second ram is extruding, and the first one is cushioning. For extrusion rams velocity control, frequency converters, controlling rotational speed of electric motors 1M1, 2M1 of pumps 1P1, 2P1, are used. Through attained in this way change in pumps delivery, flow rates of fluids powering working chambers of cylinders 1A1, 2A1, are varying. For setting a counterpressure producing cushioning forces, electrohydraulic pressure reliefs with proportional action 1V3 and 2V4, are used. Proper control of valves and frequency converters is particularly important for the quality of the extrusion process. The CEC process needs to be carried on with following working parameters set: extrusion velocity, cushioning force, maximum force of tool unit clamping, sample strain length, and number of operation cycles. The device allows cyclic extrusion of samples with maximum force of 600 kN, and velocity of extrusion rods set within range 0.1 ÷ 1 mm/s. Manoeuvring pistons velocities are significantly greater.

3 THE MEASUREMENT AND CONTROL CIRCUIT

The measurement and control circuit (figure 4) is designed to control operation of two hydraulic presses set, and for measuring and recording selected physical values during experiments with cyclic extrusion compression on samples of metals and their alloys. For realisation of algorithms controlling device operation, a PLC microprocessor controller with 32 relay inputs and outputs is applied as a central processing unit, along with: a block with 8 analog inputs, a block with 4 analog outputs, a text control desk, and a communication interface in RS232C standard. System configured in this manner allows connection of up to 8 analog signals from measurement converters.

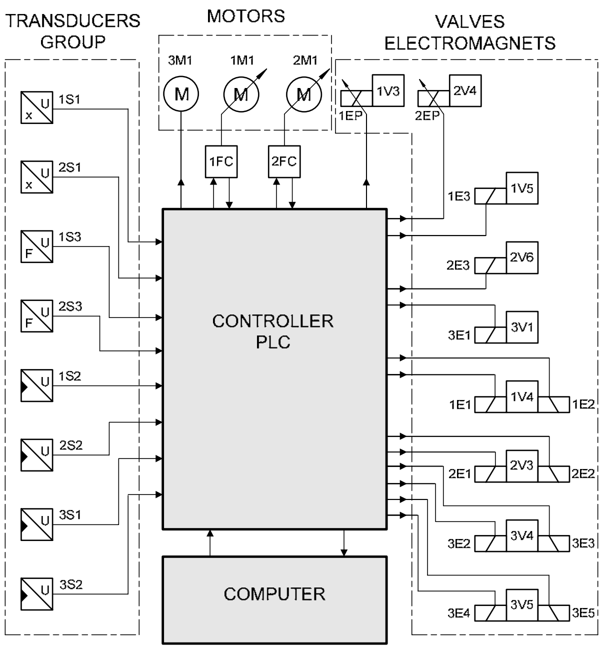

Fig. 4 The measurement and control circuit block diagram

For conducting measurements with an aid of software environment LabView, a measurement unit and a personal computer were additionally applied in described system. For piston rods 1.2, 2.2, and extrusion rams displacement measurement, contactless magnetostrictive sensors 1S1, 2S1 are applied. Pressure measurements in cylinder working chambers are performed with piezoelectric sensors 1S2, 2S2, 3S1, 3S2. Measurement of pushing force from left and right working piston rod on extrusion rams is performed by strain gauges 1D3, 2S3. This measurement is additionally controlled by measurement of pressures in appropriate chambers of cylinders. Outputs of microprocessor controller are connected to electromagnets of hydraulic directional control valves. In the hydraulic unit seven directional control valves with eleven electromagnets altogether were implemented. Moreover, two controller outputs are connected with frequency converters through 4-output block. Two remaining outputs of this block are connected with proportional electromagnets 1EP, 2EP of electrohydraulic pressure control valves 1V3, 2V4, designed for setting cushioning counter pressures. Exemplary courses of displacements sL, sP and forces FL, FP of rams 1.3, 2.3, recorded during experiment with multiple straining of material sample made of hard and soft aluminium, are presented in figure 5.

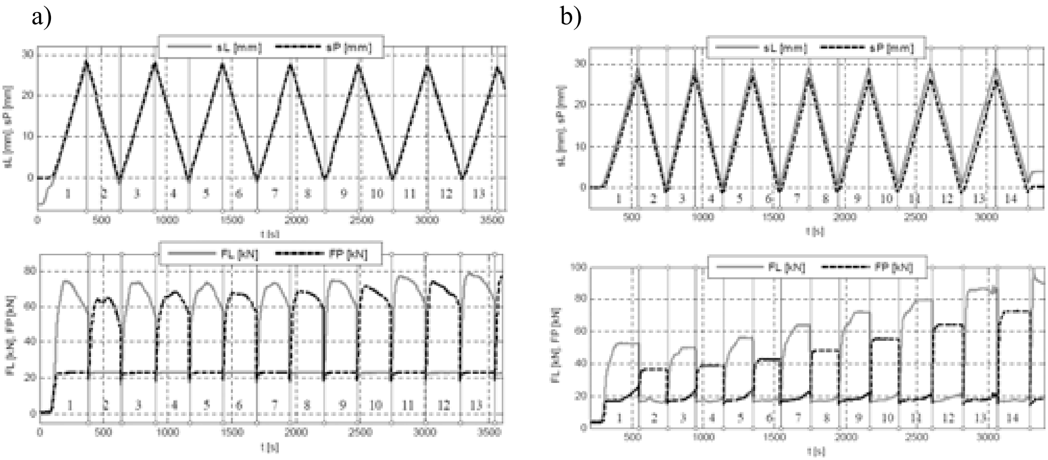

Fig. 5 Graphs of displacements sL and sP for left and right extrusion ram and corresponding extruding and cushioning forces FL and FP: a) hard material, b) soft material

4 CONCLUSIONS

Presented device was set up in „Laboratory of large plastic strains CEC" in Faculty of Non-Ferrous Metals, AGH University of Science and Technology, Krakow Poland [http://galaxy.uci.agh.edu.pl/~kppimmn]. Implementation of modern technology of electric drives, electrohydraulic proportional technology, and digital technology (PLC) for control and measurements related to CEC process course, allow conducting time-consuming research in automated manner. It leads to significant reduction of realisation time for research projects in this area. The device indicates low energy consumption and low power of applied electric motors.

REFERENCES

[1] RICHERT M., KORBEL A. 1995. *The Effect of Strain Localization on Mechanical Properties of Al99,992 in the Range of Large Deformations*. ELSEVIER Journal of Materials Processing Technology 53 (1995), ISSN: 0924-0136, pp. 331-340

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