MONOREGIME POWER UNIT

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ABSTRACT: In the paper is presented a new concept on hydrostatic drive of machine tools, which consists in the use of a single-motor multi-motor drive with speed control and braking with braking energy recovery. In this way, the energy efficiency of the drive system will be maximal. The drive system according to the new concept consists of a single hydrostatic generator that maintains the quasi-dynamic system pressure; and several hydraulic motors coupled each to a shaft or a mechanism from the machine tool.

KEYWORDS: electro-hydraulic monoregime generators, hydraulic pump, hydraulic motor, hydropneumatic accumulator, asynchronous motor, synchronous motor.

1. INTRODUCTION

The new types of electro pumps are **electro-hydraulic monoregime generators**, which convert electricity into hydrostatic energy (pressurized fluid). They are part of the one-mode drive system category. The operation of these systems is based on a new concept. **The new concept** involves the creation of a drive system generally formed from: *a hydraulic energy generator, a **hydrostatic** energy accumulator, and a hydraulic engine (s)*, in which two *energy transformations, primary transformation and secondary transformation* are produced. *The primary transformation* is made by the energy generator, which transforms the energy (electric) into hydrostatic energy. *The secondary transformation* is accomplished by the hydraulic motor (s), which takes the energy stored in the accumulator and converts it into mechanical energy, generally in the form of rotational motion [1], [2].

2. SYSTEM OVERVIEW

In the **Figure 1** shows the operating diagram of the drive system monoregime [3]. The main parts of the engine are: ***GH** Hydraulic Generator; **AH** hydraulic accumulator, and **MH** (s) hydraulic engine (s).* The system is also fitted with the hydraulic fluid *reservoir **Rz*** and the **SCM** engine control system. The **GH** Hydraulic Generator converts incoming (electrical) energy into hydrostatic energy, which is transmitted and stored in the **AH** battery. The **AH** hydraulic accumulator is generally *hydropneumatic*, which besides the role of hydrostatic energy storage also has the role of damping the flow pulses and hydraulic shocks [5], [6], [7].

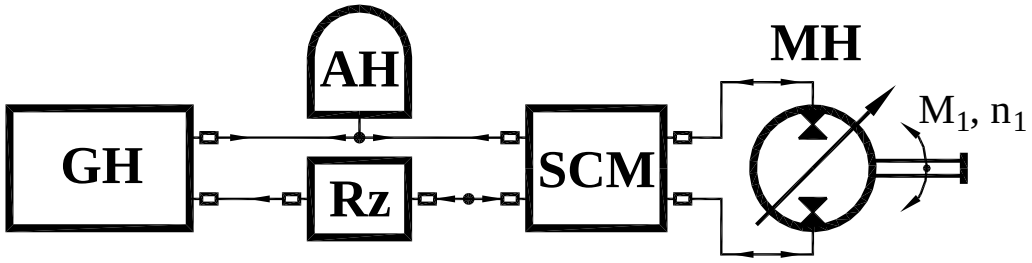

Figure 1. The operating diagram of the drive system monoregime

The **MH** hydraulic motor takes over and converts the hydrostatic energy from the battery into mechanical energy, generally in the form of rotational motion, with the following parameters: $\boldsymbol{M_1}$ is the engine moment in *N·m*; $\boldsymbol{n_1}$ is the shaft speed in *rot/min*. Rotary motion parameters can be adjusted or maintained constantly with the **SCM** engine control system, which changes the volumetric capacity of the **MH** hydraulic motor [8]. Also with the **SCM** control system, *braking with braking energy recovery* can be achieved by passing the hydraulic motor **MH** (reversible machine) in pump mode; and *reversing the direction of rotation*.

The monoregion drive system has the following **advantages**: **Low power consumption**. The generator only works in *one mode and no idle moments*. The electrical part of the generator can operate in *synchronized mode*, with a power factor equal to the unit ($\cos\varphi = 1$). In this case, no reactive power is consumed and the yield is maximum. It can also **partially or totally take over the drive functions** (torque, speed, and torque change), including **braking with braking energy recovery**.
The current large-scale drive systems, especially the electric ones, have the disadvantage that they are made up of several motors coupled directly to the workpiece shafts. In these cases, the electrical power is distributed to several motors, each having a lower efficiency than a high power motor equal to the system. Also, for regulating the speed or maintaining it constantly, system motors must be equipped with complex electronic devices (power converters) that reduce efficiency.

3. HYDROSTATIC ENERGY GENERATOR WITH WORKING IN ONE SINGLE REGIME

The main elements of the mono-hydraulic hydraulic generator are: the **ME** electric motor (asynchronous or three-phase synchronous); hydraulic pump **P**, reversible with constant volume capacity; and the **Ac** hydraulic accumulator (Figure 2). The generator is also equipped with an automatic control and control system and a hydraulic fluid reservoir **Rz** [4].The automatic control and control system consists of the **CE** electronic contactor, the **Th**-speed transducer, the **SP** pressure transducer and the **PlH** hydraulic plate with the hydraulic elements for the pump running in the engine mode and reverse.
The generator operation is as follows: generator startup occurs when drive system pressure drops to the minimum admissible value $ph1_{min}$; and the generator stops when the operating system pressure increases to the maximum admissible value $ph1_{max} = ph1_{min} + \Delta p$, where $\Delta p = (5 - 10)\ bar$.
When the pressure in the drive system decreases to the minimum allowable value, the pump **P** is switched to engine mode, which drives the **ME** electric motor up to the synchronous speed. At this moment, the **ME** electric motor is connected to the power supply by the electronic contactor **CE**, and the hydraulic pump **P** is switched to pump mode. Due to this startup mode, it is avoided to leap the current of the mains, which can be 5 to 8 times higher than the rated current.
When the pressure in the drive system increases to the maximum allowable value, the **ME** motor is disconnected from the mains by the electronic contactor **CE**.
Thanks to this mode of operation, the **generator only operates in one mode** (no start and idle mode), **automatically on the start-up** principle.

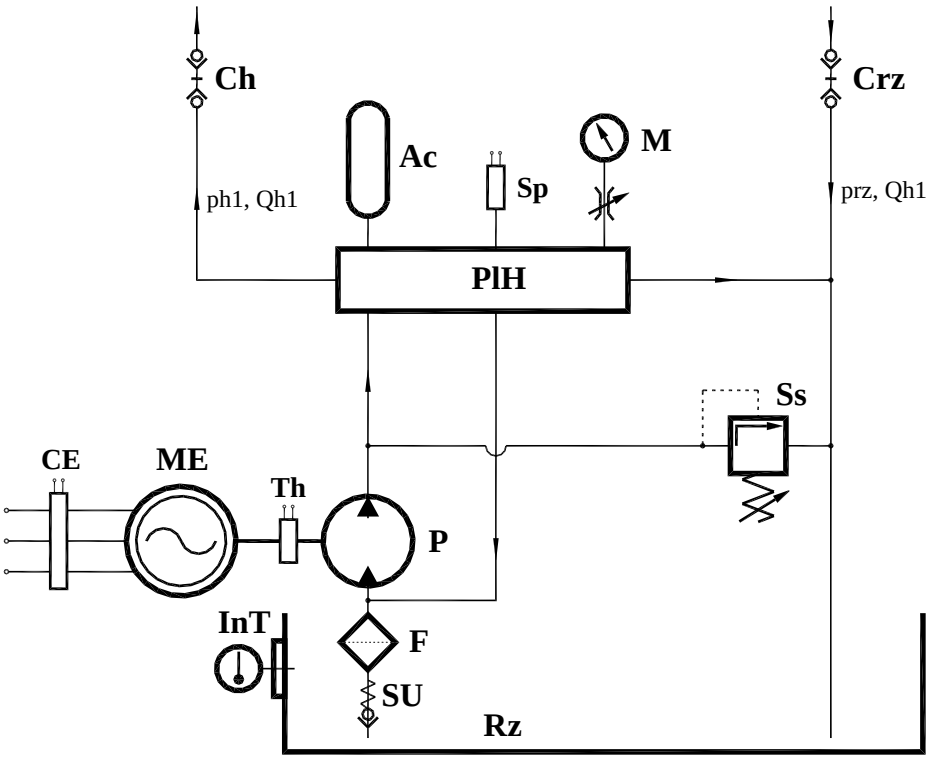

Figure 2. The working scheme of the monoregim generator

4. EXAMPLES OF APPLICATION

A prototype single-mode hydrostatic energy generator with working in one single regime was designed to perform the experimentation with the following main parameters: the flow rate at 1500 rot/min is 14 l / min; maximum operating pressure 200 bar (Figure 3).

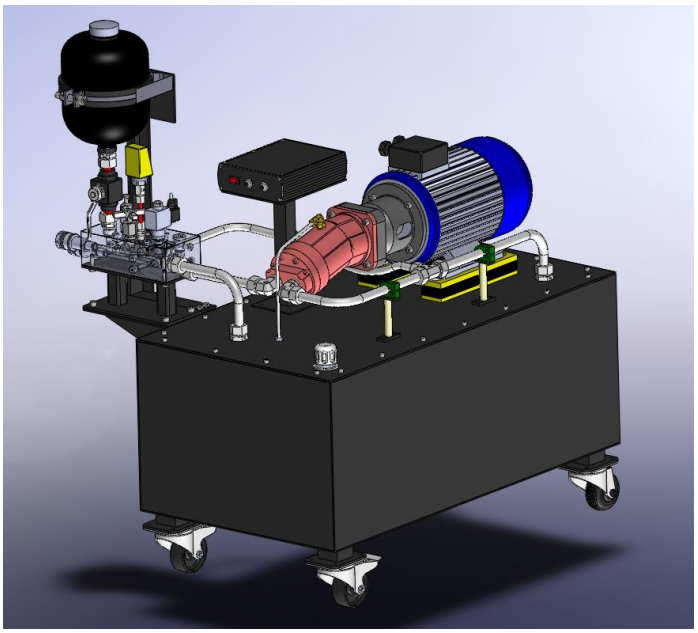

Figure 3. The prototype hydrostatic energy generator

The **generator** consists of the following subassemblies: pumping group, hydraulic system, and electronic control and control system (Figure 4).
Pumping group consists of: *electric motor*, *reversible hydraulic pump* with constant volumetric capacity, *electric motor support*, vibration damping, *hydraulic pump support*, and *elastic coupling*.

Hydraulic system consists of: *hydraulic plate*; *oil reservoir*; and *connecting pipes*. **The hydraulic plate** is provided with the following *hydraulic elements*: control distributor; unlocking sense valves; sense valve; overpressure safety valve; overload safety valve; coupling devices; pressure relay; and hydraulic accumulator (Figure 5).

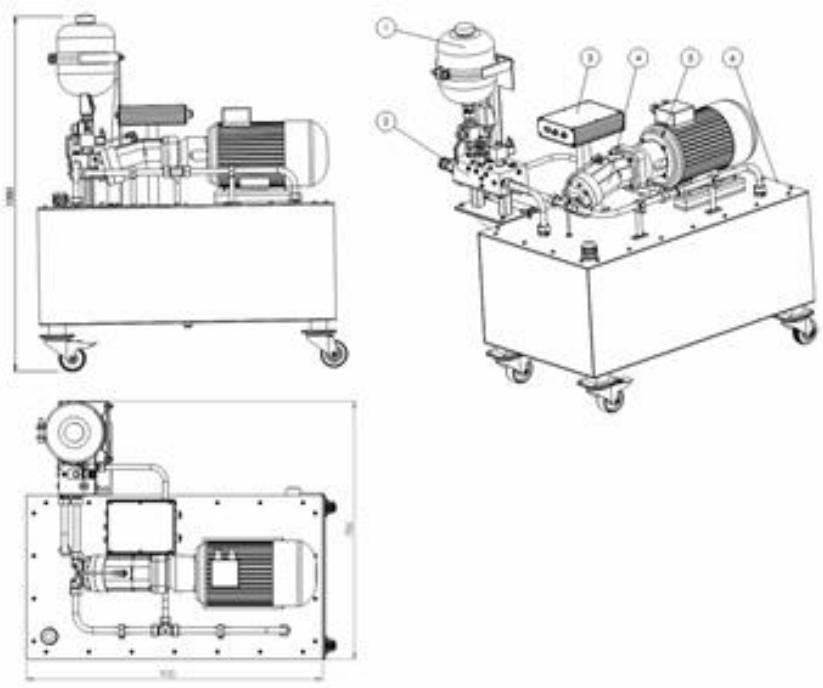

Figure 4. Dimensions and parts of the prototype

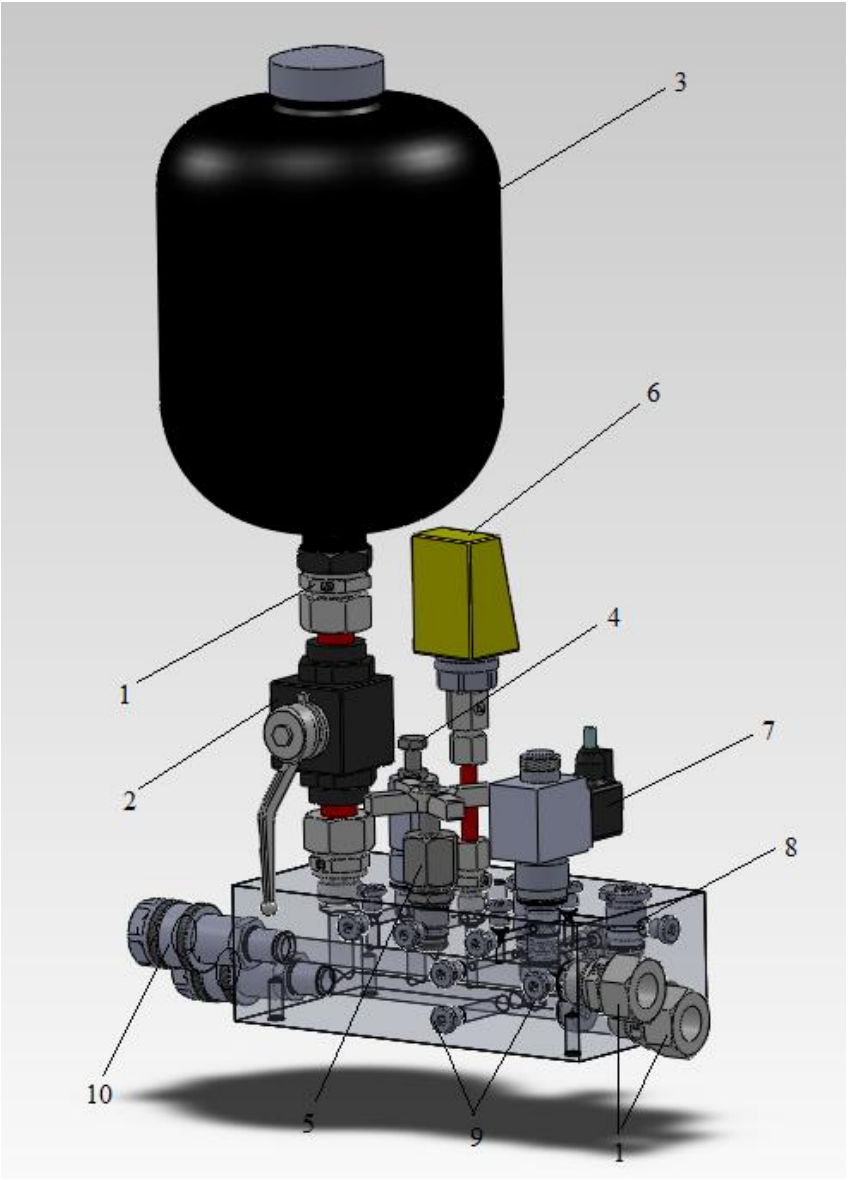

Figure 5. Dimensions and parts of the prototype

The electronic control system and functional model control, consists of electronic elements: *electronic contactor, printed circuit board, power supply, and electric switch*. The block diagram of the electronic control system is shown in Figure 6.

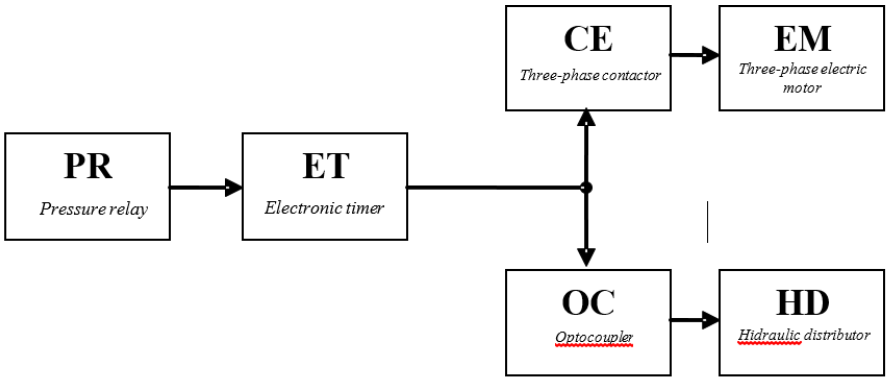

Figure 6. Block diagram of the electronic control system

PR – Pressure relay (or sensor **SP**); **ET** – electronic timer; **CE** – three-phase cotactor monolitic; **EM** – electric motor; **OC** – optocoupler electronic; **DH** – hidraulic distributor; **AH** – the hydraulic energy accumulator.

The operation of the automated control system is based on the processing, delay (required to bring the **EM** electric motor at the synchronization speed via the hydraulic pump **PH** in the *engine mode*) to the signal received from the **PR** relay to command the delayed start of the **EM** electric motor when the hydraulic system pressure reaches the preset minimum threshold.

5. CONCLUSIONS

The general solution adopted to increase the energy efficiency of hydrostatic drive on machine tools is **volumetric regulation and braking with brake energy recovery**. Volumetric adjustment enables the kinetic and dynamic parameters of mechanical movement to be changed theoretically without losing energy.

The new concept is a multi-engine monogenerator with variable speed control and braking with brake energy recovery.

The main elements of the new drive system are: The **hydrostatic energy generator** will be auto-running in one mode, which will provide quasi-dynamic pressure in the drive system; **Hydraulic motors** with adjustable capacity for actuating workpieces or machine tool mechanisms that perform all the functions of a drive: acceleration, constant angular or linear velocity, and braking with braking energy recovery.

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