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NEW CONCEPT FOR THE RUNNING OF ENGINES

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The new concept as for the running of engines is to consist, in the motor machine from *energy accumulator* of energy supply. Charging the energy accumulator is made of an energy generator, which *running in a single regime* (monoregime) with maximum efficiency. The concept involves the development of engines, and, generally consist of: *energy generator*, *energy accumulator* and *motor machine***,** in which two energy transformation occur, the primary transformation and the secondary transformation. The primary transformation is realized by the energy generator, which transforms the input energy (thermal or electric) to another form of energy (fluid energy). The energy produced by the generator is stored in the energy accumulator. The secondary transformation is realized by the motor machine, which takes over the energy stored in the accumulator and transforms it in mechanical energy, usually under the form of a rotation movement. The engine running efficiently if the energy generator, fulfils the following conditions: to produce a form of energy that can be easily stored in the energy accumulator and can be easily transmitted to the motor machine; to run in a single regime, automatic on the principle **start-stop**, characterized by starting automatically, when the energy in the accumulator has the minimum admitted value, and stopping automatically, when the energy in the accumulator has the maximum admitted value. The energy forms which fulfil the above mentioned conditions are: the hydrostatic energy; and the pneumatic energy. *The new concept* as for the running of engines in a single regime (monoregime engines), *represents a new research direction*, obviously, is much easier to optimize a single regime, compared to an infinity, as to produce the current engines.

Key words: Drive system; Internal combustion engine; Electric motors; Free piston; Hydraulic accumulator hydraulic engine; Hybrid engine; Monoregime thermic engines; Monoregime thermopump; Monoregime electric engines; Monoregime electropump; Eelectric oscilomotor.

1. GENERAL CONSIDERATION

The engine is the main part of the drive system from the motorized machine. It aims to transform a certain form of energy (thermal energy, electrical energy) into mechanical energy, usually in the form of a rotating motion. In a drive system, the mechanical energy transmission from driving motor of the working machine in a continuous mode to produce, by coupling the engine shaft at the parts of working machine, directly or through a transmission [2, 5, 6, 9, 10]. The scheme of the system drive is as follows: the transmission **TR**, which there is to insert between the motor machine **MM** (thermal engine, electrical motor) and the working machine **ML**, change the mechanical parameters of the engine shaft (torque M_1, angular velocity ω_1) (Fig. 1).

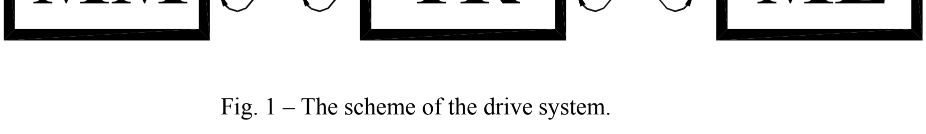

Fig. 1 – The scheme of the drive system.

The run drive system is stable, if the power produced by the driving motor is equal to the power needed to the working machine drive: $P_1 = P_2$ or $\omega_1 \cdot M_1 = \omega_2 \cdot M_2$. In general, the power needed to the working machine varies during the running progress of the drive system. To ensure a stable running system, is necessary to vary the driving motor power exactly as well as the power of the working machine. Varying the driving motor power is to carry out by energy consumed dosage devices (flow of fuel or flow of thermic agent – for thermal engines; the voltage, the current intensity, or the current frequency – for electric motors) [1, 2, 5, 6 9]. If the power needed to the working machine is constant, the driving motor to run in stationary regime. The torque and angular velocity is constant: $M_1 = ct.$; $\omega_1 = \text{ct.}$ If the power needed to the working machine is variable, the driving motor to run in transitory regime. The torque and angular velocity is variable: $M_1 \neq \text{ct.}$; $\omega_1 \neq \text{ct.}$ (with some exceptions, for example, the angular velocity to the electric synchronous motor is constant and in transitory regime). The transitory regime is the transition period a stationary regime to another, of the driving motor. The variation of the driving motor is more intense with both the operating conditions of the driving motor are more difficult and efficiency is lower.

2. NEW CONCEPT FOR THE RUNNING OF ENGINES

The new concept for running of engines is developed starting from ener*gy accumulator* of *energy supply*. Charging the *energy accumulator* is made by an *energy generator*, which runs in a *single regime* (monoregime) with *maximum* efficiency. The concept involving the development of engines, generally consist of: *energy generator* **GE**, *energy accumulator* **AE** and *motor machine* **MM,** in which two energy transformation occur, the *primary* transformation and the *secondary* transformation (**fig. 2**) [3], [4]. *The primary transformation* is realized by the energy generator, which transforms the input energy (thermal or electric) to another form of energy (different from the mechanical energy – fluid energy). The energy produced by the generator is stored in the energy accumulator **AE**. *The secondary transformation* is realized by the motor machine **MM**, which takes over the energy stored in the accumulator and transforms it in mechanical energy, usually under the form of a rotation movement.

Fig. 2 – The running scheme of monoregime engines.

The engine running is as follows: the generator **GE** transmits the produced energy to the accumulator **AE** until the energy in the accumulator reaches its maximum admitted value. In this moment, the accumulator automatically stops running until the energy in the accumulator drops to the minimum admitted value/level. In this way, the generator **GE** may run *in one regime only* with maximum efficiency, independently from *the working regime* of the motor machine **MM**. The motor machine takes over the energy from the accumulator and transforms it in mechanic energy according to the consumption realized by the working parts of the system. The energy flow can go both directions generator-accumulator and reverse, or accumulator-motor machine and reverse.

The engine running efficiently if the energy generator **GE** fulfils the following conditions: to produce a form of energy that can be *easily stored* in the energy accumulator **AE** and can be *easily transmitted* to the motor machine **MM**; to running *in a single regime, automatic*, on the principle ***start-stop***, characterized by *starting automatically*, when the energy in the accumulator has the minimum admitted value, and *stopping automatically*, when the energy in the accumulator has the maximum admitted value.

The energy forms which fulfil the above mentioned conditions are: the *hydrostatic energy*; and the *pneumatic energy*. *The hydrostatic energy* can be used in a *large scale* of power and application domains. The hydrostatic drives are well known and considered to be superior compared to the other existing drives [7, 8, 10]. *The pneumatic energy* may be used at low power. In general, the pneumatic drives, is used in restricted areas of activity. After to the energy form that we produce, generators are classified in: *hydrostatic* *generators* and *pneumatic generators*. The hydrostatic generators which transform the thermal energy are called *monoregime thermopumps*, while those which transform the electric energy are called *monoregime electropumps*. *The energy accumulator* is a normal hydraulic accumulator [8]. The *motor machine* is a rotational hydraulic engine(s) with adjustable capacity. These types of engines allow the variation of the rotation on a large scale and can recover the braking energy [7, 8, 10].

The monoregime engines belong to the category of hybrid *termohidraulic* or *electrohidraulic* engines. They represent an *absolute novelty*. Hybrid engines are known hybrid *thermoelectric* engines (hybrid series and parallel hybrid) which produce *three conversions* energy: the thermic energy is transformed in mechanic energy (through the heat engine); the mechanic energy is transformed in electric energy (through electric energy generator); the electric energy is transformed into mechanic energy (through electric engines) or it is stored in electric accumulators. The new engines there to produce *only two energy transformations*: thermic or electrical energy is transformed into a hydrostatic or pneumatic energy (through the energy generator); the hydrostatic or pneumatic energy is transformed into mechanic energy (through hydraulic or pneumatic engines). The new concept for running of engines in a single regime (monoregime engines), represents *a new research direction*. Obviously, is much easier to optimize a single regime, compared to an infinity as to produce the current engines.

3. MONOREGIME ENGINES

The monoregime thermic engines transform the thermo energy, to obtain by combustion of fuel (petrol, Diesel oil, non-conventional fuels), into mechanic energy, generally as a rotary motion. The main parts of the engine are: the monoregime thermopump **TM**; the hydraulic accumulator **AH**; and the hydraulic engine **MH** (Fig. 3a). The engine is equipping more with the fuel reservoir **RC** and the reservoir for hydraulic fluid **RH**.

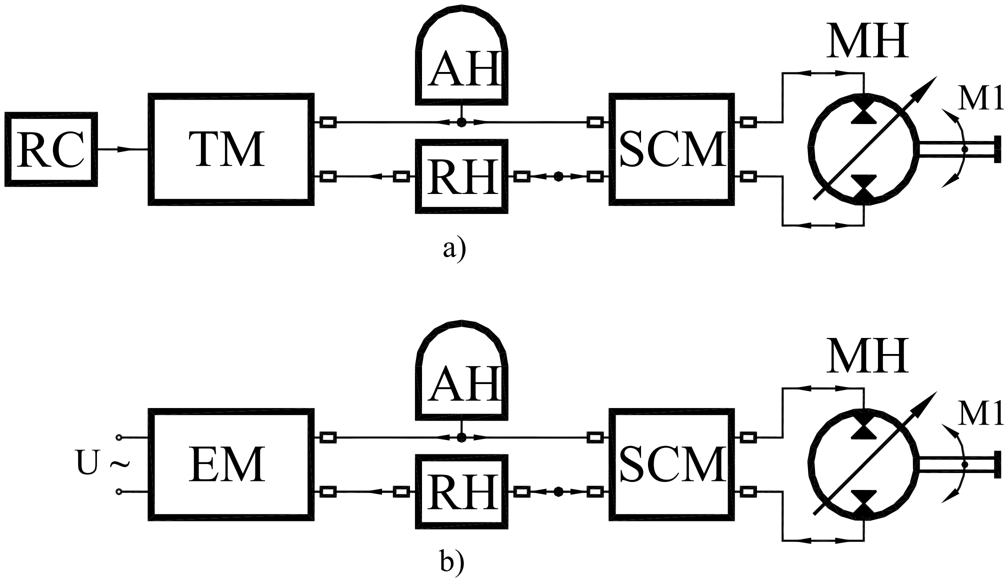

Fig. 3 – The running scheme of monoregime thermic engines.

The monoregime thermopump transforms the thermic energy obtained by combustion of fuel in hydrostatic energy. The hydrostatic energy produced by monoregime thermopump is stored in the *hydraulic accumulator*. The hydraulic engine supply of energy is through the command system engine **SCM**.

The monoregime electric engines transform the electrical energy into mechanical energy, generally as a rotary motion. The main parts of the engine are: monoregime electropump **EM**; hydraulic accumulator **AH**, and hydraulic engine **MH** (Fig. 3b). The engine is equipped with the reservoir for hydraulic fluid **RH**.

The monoregime electropump transforms the electrical energy in hydrostatic energy. The hydrostatic energy produced by monoregime electropump is stored in the hydraulic accumulator. The hydraulic engine energy supply is through the command system engine **SCM**. The hydraulic engine transforms the hydrostatic energy into mechanic energy necessary to drive the working machine.

3.1 The monoregime thermopump

The main part of the monoregime thermopump consists of two cylinders: *the motor cylinder* **CM** and the *hydraulic cylinder* **CH** linked coaxially, and inside them the free piston **PL** has an alternating-rectilinear motion (Fig. 4) [3, 4]. The free piston is the only mobile part, without articulated elements. The starting-stopping of the head strokes piston to not adversely affect the running of the generator, because the speed and kinetic energy is zero at the ends of the stroke.

Because of the movement of the piston, between the walls of the cylinder and the piston four chambers with variable volumes are formed: *the thermal chamber* **T**; *the compression chamber* **C**; *and the hydraulic chambers* **H1** and **H2**. The piston motion is made under the action of the pressure forces of the gases from the thermal and compression chambers, and of the pressure forces of the hydraulic liquid from **H1** and **H2** chambers. In the thermal room take place the *processes of the thermal cycle,* in the compression room take place processes of air aspiration necessary to supercharge or to form an accumulation of pneumatic energy necessary for the movement of the piston. In the hydraulic chambers take place *processes of pumping* (suction-discharge) of the hydraulic liquid. The piston movement is coordinated by the *automatic command system* **SAC**. Information regarding the piston position is provided by the *transducers* **TH**. The piston moves between **pvm** (point of minimal volume) and **pvM** (point of maximum volume). The forces which operate on the piston are the $\boldsymbol{F_M}$, force created by the pressure of the gases in the thermal and compression chamber, and the F_H force, created by the pressure of the hydraulic liquid from **H1** and **H2** chambers. The F_M force has a great variation (exponential) during the stroke progress of the piston, and the F_H force is quasi-constant.

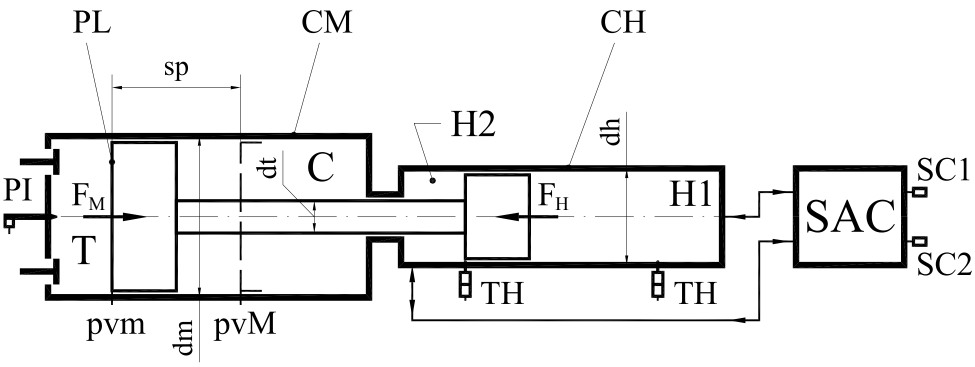

Fig. 4 – The running scheme of monoregime thermopump.

The thermodynamic processes of the thermal cycle from monoregime thermopump are identical to the thermodynamic cycles of internal combustion engines. As the internal combustion engines, thermal cycle from monoregime thermopump can take place at two strokes *(two stroke thermo pumps*) or at four strokes (*four stroke thermo pumps)*. The hydraulic energy to stock in the hydraulic accumulator the progress duration a thermal cycle is determined by the following relation:

$$W_H = \eta_{tp} \cdot \oint \left[p_T(x) - p_c(x) \right] \cdot \mathrm{d}V, \tag{1}$$

where: η_{tp} is total efficiency of the monoregime thermopump; $p_T(x)$ is the function of variation of the pressure gas in the thermal chamber; $p_C(x)$ is the function of variation of the pressure gas in the compression chamber; x is the position piston from the origin point of the coordinates axis. The value of total efficiency of the monoregime thermopump is dependent on the energy losses that occur the progress duration a thermal cycle: loss of energy produced by the forces of friction; energy loss caused by the hydraulic fluid viscosity; the energy consumed to move the piston of the strokes of the fresh load admission and the exhaust gases, if the four-stroke monoregime thermopump, etc.

The power monoregime thermopump is determined by the following relation:

$$P_H = f_{ct} \cdot W_H = p_{ha} \cdot Q_p\,, \tag{2}$$

where: f_{ct} is the progress frequency of the thermal cycles; p_{ha} is the hydraulic fluid from the hydraulic accumulator; Q_p is the monoregime thermopump flow.

By solving the equations (1) and (2) (computation of the thermodynamic cycle) is obtained and the following sizes: the diameter d_m of the motor cylinder; the length of stroke s_p of the piston motion; and the minimum volume of the thermal chamber.

During the compression stroke progress of the fresh load the hydraulic chambers are in connection with the hydraulic accumulator. The feature function $F_C(x)$ for the compression stroke is defined by the relation:

$$F_c(x) = \frac{m_p \cdot w_{pc}^2(x)}{2} - L_C(x), \tag{3}$$

where: m_p is the mass piston; $w_{pc}(x)$ is the function of variation of the piston speed to the compression stroke; $L_C(x)$ is the function of variation of the mechanical work developed of the compression stroke, by the gas pressure of thermal and compression the chamber, and the hydraulic liquid pressure of the hydraulic chambers.

During the expansion stroke progress of the flue gases the hydraulic chamber **H1** are in connection with the hydraulic accumulator and the hydraulic chamber **H2** are in connection with the hydraulic fluid. The feature function $F_D(x)$ for the expansion stroke is defined by the following relation:

$$F_d(x) = \frac{m_p \cdot w_{pd}^2(x)}{2} - L_D(x), \tag{4}$$

where: $w_{pd}(x)$ is the function of variation of the piston speed to the expansion stroke; $L_D(x)$ is the function of variation of the mechanical work developed of the expansion stroke, by the gas pressure of thermal and compression the chamber, and the hydraulic liquid pressure of the hydraulic chambers.

If the kinetic energy theorem to apply to the compression stroke and to the expansion stroke of the piston, to obtain the following system of equations:

$$\begin{cases} F_c(x_0 + s_p) - F_c(x_0) = 0 \\ F_d(x_0) - F_c(s_p + x_0) = 0 \end{cases}, \tag{5}$$

where: x_0 is the position **pvm** from the origin point of the coordinates axis; s_p is the length of stroke of the piston motion. The solutions of the system equations (5) to represent, the size of the diameter d_h of the hydraulic and the size the diameter d_t of piston rod.

The function of variation of the piston acceleration from the expansion stroke of the flue gases is defined by the following relation:

$$a_{pd}(x) = \frac{\mathrm{d}}{\mathrm{d}\tau} w_{pd}(x) = w_{pd}(x) \cdot \frac{\mathrm{d}}{\mathrm{d}x} w_{pd}(x). \tag{6}$$

The piston mass is determined from the condition of limiting the maximum piston speed of the expansion stroke from a certain value $w_{p\,\max}$. Maximum speed is the point x_a where the piston acceleration is zero:

$$a_{pd}(x_a) = 0. \tag{7}$$

The solution of the equation (7) to represent, the size of the coordinate x_a. If the kinetic energy theorem to apply between **pvM** and the point x_a, obtain the relation of computation for piston mass:

$$m_p = \frac{2}{w_{p\,\max}^2} \cdot L_D(x_a). \tag{8}$$

The time of progress of one stroke i of the piston, is determined by the relation:

$$\tau_{pi} = \frac{S_p}{\overline{w}_{pi}} = \frac{S_p^2}{\int_{x_0}^{x_0+S_p} w_{pi}(x) \cdot \mathrm{d}x}, \tag{9}$$

where: $w_{pi}(x)$ is the function of variation of the piston speed of the stroke i; $\overline{w}_{pi}$ is the piston average speed of the stroke i.

The frequency with which it conducts thermal cycle is calculated by the relationship:

$$f_{ct} = \frac{1}{\sum_{i=1}^{\nu} \tau_{pi}}, \tag{10}$$

where: ν the number of piston strokes of one thermal cycle, $\nu = 2,\ 4$.

In conclusion, the monoregime thermopumps *characterized* by the following features: *running in a single regime* (monoregime), automatic running on the principle *start-stop*; without moment's *idle running*; have *only one mobile element* an alternating-rectilinear motion.

3.2 The monoregime electropump

Part of the monoregime electropump consists of two *hydraulic cylinders* **CH,** coaxially and symmetry to dispose, and inside them the free piston **PL** has an alternating-rectilinear motion (Fig. 5). Of the piston rod is fixed rigidly the mobile core irons **AM** of the electric oscilomotor.

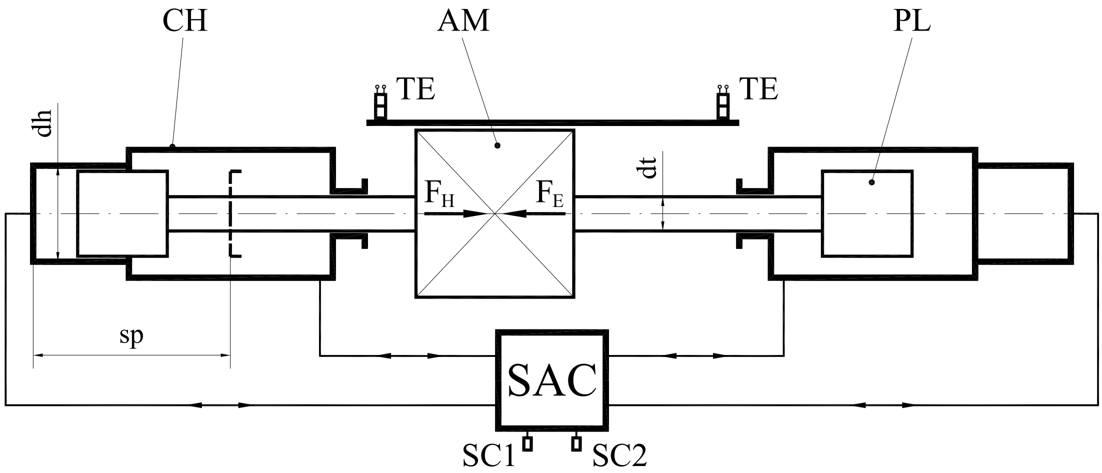

Fig. 5 – The running scheme of monoregime electropump.

The piston and the core irons is the only mobile part, without articulated elements. The mobile part starting-stopping of the head strokes to not adversely affect the running of the generator, because the speed and kinetic energy is zero at the ends of the stroke. The mobile part movement is coordinated by the *automatic command system* **SAC**. Information regarding the piston position is provided by the *transducers* **TE**. The forces which operate on the mobile part are, the F_E electromagnetic force, created by the electromagnetic energy at the electric oscilomotor, and the F_H force, created by the pressure of the hydraulic liquid from the hydraulic cylinders. The F_E force has a sinusoidal variation during the stroke progress of the mobile part, and the F_H force is quasi-constant.

The hydraulic energy developed during a stroke is determined by the following relation:

$$W_H = \eta_{ep} \cdot W_E, \tag{11}$$

where: η_{ep} is total efficiency of the electropump; W_E is the electromagnetic energy developed the electric oscilomotor in a stroke to the mobile part.

The value of total efficiency of the monoregime electropump is dependent on the energy losses that occur the progress duration a stroke: loss of energy produced by the forces of friction; energy loss caused by the hydraulic fluid viscosity; loss of electric energy in electric oscilomotor, etc.

The power monoregime electropump is determined by the following relation:

$$P_H = f_{sp} \cdot W_H = p_{ha} \cdot Q_p = \eta_{ep} \cdot P_{el}, \tag{12}$$

where: f_{ct} is the progress frequency of the strokes; p_{ha} is the hydraulic fluid from the hydraulic accumulator; Q_p is the monoregime electropump flow; P_{el} is the effective power of the electric oscilomotor.

The electric oscilomotor feeds from a network of alternating current frequency: $f = 50\ \text{Hz}$ or $60\ \text{Hz}$. In these conditions, the frequency of strokes is: $f_{sp} = 2 \cdot f = 100\ \text{Hz}$ or $120\ \text{Hz}$.

During a stroke progress, the chambers with variable volume formed in hydraulic cylinders are made in relation to alternative by the hydraulic accumulator or by the reservoir for hydraulic fluid of the *automatic command system* **SAC**. In the first half of the stroke is accelerating the mobile part, and the other half of the stroke is to braking. Further on, the stroke with left-right direction to analyze (see Fig. 5). In the stroke of acceleration, in the hydraulic cylinder on the left two chambers with variable volume (the chamber fore and behind the piston) to form, and the hydraulic cylinder on the right a single chamber with variable volume to form. The chamber fore the piston and the chamber formed in the cylinder on the right are made in connection with the hydraulic accumulator, and the chamber behind the piston is made in relation to the reservoir for hydraulic fluid. Further on, the stroke of braking, in the hydraulic cylinder on the left a single chamber with variable volume to form, and the hydraulic cylinder on the right two chambers with variable volume (the chamber behind and fore the piston) to form. The chamber formed in the cylinder on the left and the chamber behind the piston is made in relation to the reservoir for hydraulic fluid, and the chamber fore the piston made in connection with the hydraulic accumulator. The feature function $F(x)$ for one stroke of the mobile part is defined by the following relation:

$$F(x) = \frac{m_p \cdot w_p^2(x)}{2} - L(x), \tag{13}$$

where: m_p is the mass piston; $w_p(x)$ is the function of variation of the mobile part speed to one stroke; $L(x)$ is the function of variation of the mechanical work developed to one stroke, by the hydraulic force of the hydraulic cylinders and the electromagnetic force, developed by the electric oscilomotor.

If the kinetic energy theorem to one stroke of the mobile parts (the stroke with left-right direction) to apply, to obtain the following equation:

$$F(x_0 + s_p) - F(x_0) = 0, \tag{14}$$

where: x_0 is the end position of the stroke left, from the origin point of the coordinates axis; s_p is the length of stroke of the piston motion.

The relationship between the frequency of progress of the strokes, the stroke length, and the movement speed of the mobile part is given by the following equation:

$$f_{sp} \cdot S_p^2 = \int_{x_0}^{x_0+S_p} w_p(x) \cdot \mathrm{d}x. \tag{15}$$

By solving the system equations (14), (16) and (17) is obtained and the following sizes: the diameter d_h of the hydraulic cylinders; the diameter d_t of piston rod; and the length of stroke s_p of the piston motion.

In conclusion, the monoregime electropumps characterized by the following features: running in a *single regime* (monoregime), automatic running on the principle *start-stop*; without moment's *idle running*; have only *one mobile element* an alternating-rectilinear motion.

4. CONCLUSIONS

The monoregime concept represents a *new research direction*, which allows *new types of engines* to implement with increased performance and lower consumption of fuel or electricity [3, 4].

The monoregime engines characterized by the following ***specific features***: running in a single regime (monoregime); without moment's idle running. We estimate the following ***advantages*** (compared to the nowadays drive systems by internal combustion engines or by electric motors): less fuel consumption or electrical energy, reduced pollution (it is much easier to optimize a single regime, compared to infinity, as to produce the current engines); simple construction; and good viability. Also, the monoregime engine can to *assume*, total or part, the transmission functions (control torque, speed and direction of rotation), including the function of braking with the recuperation energy.

For example, in the event of motor vehicles driven by monoregime thermic engines, partially to eliminated the transmission (clutch, reduction gear, gearbox, longitudinal transmission) when the monoregime thermic engine have a single motor machine (hydraulic engine), or totally to eliminated the transmission when the monoregime thermic engine have two or four motor machines (hydraulic engines) [7], [8]. The hydraulic engines if to pass as pump regime produce the braking (an efficient braking can be made, without blocking the wheels) and with braking energy recovery. Also, removes the control systems (the electronic system of the group of propulsion, etc.), and starting system.

The monoregime electric engine as well monoregime thermic engines, can to assume part or all the functions of the transmission. By coupling a hydraulic motor at each shaft of the work element, to obtain a complex drive system, with superior indices on performance and on energetic to those achieved of current drive systems by electric motors equip with converter. The converters have the disadvantage that distorts the variation wave at voltage and at intensity of electric current. The variation of the deformity waves differ substantially from sinusoidal variation. Due to this deformation (deformed regime), producing the following negative effects: increase electricity consumption (to reduce the efficiency and the power factor of consumers: electric motors, electric apparatuses, etc.), producing radio-telephone disturbance, increases the measurement errors to the measuring apparatuses [5]. The electric part of the monoregime engine, running only in a single regime with maximum efficiency, and without moment's idle running. The electrical power of oscilomotor is equal to the power driver system, resulting in an oscilomotor by great power and high efficiency. At the current systems, the electrical power is distributed to several motors, resulting electric motors by low powers and decreased efficiency. Also, the overall size and the power mass ratio of the hydraulic engines are more reduced than that of the electric motors.

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