Power optimization of the complex pumping system

A. Alexandrescu
Department of Machine Manufacturing and Industrial Management, Technical University Gheorghe Asachi, Iasi, Romania

Abstract

This paper proposes a solution to the problem of reducing production costs for supplied domestic water, which directly affects the reduction of electric power consumption. The paper presents the methodology and the program of calculus for the transport's optimization of the water under pressure in the system of supply with water of Iasi city. The optimization process will take into account that the profitability of water distribution activity depends on the relationship between supply capability and operating costs. Therefore, the process depends on the volume of required investment, on the specific consumption electrical power for pumping, on the price of electricity, as well as on the volume of water billed on a monthly basis. The optimization calculation will use two target functions: total maximum efficiency and total electric power consumption required for transport of each cubic meter of supplied water, and cubic meter of sewage water, respectively. The mathematical methods may be improved by taking into account all active consumers in the network with simultaneous water requirements, at each moment of the day.

Keywords: adduction, flow, hydrophore, pipe network, pump, tank.

1 Introduction

The paper shows a determination method about the pumping installation's average global output in the adjustment situation through hydro – pneumatic heads. It is presented an analyze method about power and economical efficiency of the pumping installations equipped with only one type of pumps. The adaptation to variable regimes is done by the hydrophore's usage. The best power and economical performances will correspond to the pumping solution

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which ensures the covering of the request area flow, head (Q, H) with the best outturn.

The theoretical considerations are accompanied by the examples concerning an under pressure station from a collective system about supplying with urban water.

Profitability of water distribution activity depends largely on the relationships between operational capability and service costs, related to supplier's performance, volume of distributed water and effective operating costs [1]. The main variables that influence the total selling price are required investment value, specific consumption of electrical energy for pumping power, unit price of the electrical energy and total volume of monthly consumed water billed. The selection of rehabilitation and modernization measures must rely on market studies results that appropriately establish the quantities of water that may be distributed and billed. Present and future water requirements will be determined based on the analysis of actual operation data and on estimation of future trends in water consumption on national and international levels.

Authors used original mathematical algorithms to develop original computer programs that calculate, at each moment in time, depending on the number of active consumers connected simultaneously to the network, the functional parameters of the ensemble pumping station – hydrophore – pipe distribution network, as well as the available consumer parameters. This may be done in the hypothesis of a minimum price of cubic meter of pumped water.

The automatic calculation program defines the exploitations regimes for the overall output's installation to be maximum and the total typical energy consumed to be minimum on the work cycle ensemble.

2 Optimization problem's wording

The pumping efficiency is established by studying technical implications of modernization measures of the power station. Energy efficiency and economic efficiency for the pumping supply system are tightly connected to the proper choice of pumping device and appropriate operation of the hydraulic system. The best performances are obtained when, in order to meet the consumer requirement, the pumps are set to operate for regimes with efficiencies that are close to their maximum values. The equipment required for the pumping station must meet the operational characteristics of the network, as well as the relationships between the flow rate and specified hydraulic energy required by pumps, depending on various operational configurations.

The paper presents the authors efforts to find the optimum solutions to ensure proper servicing of consumers, 24 hours a day, and reduction of operation costs, proposing the following measures:

1. Rehabilitation of pumping stations, as the capacity of supply has to meet the requirements of the consumers and to take into account the present trend in domestic heating and hot water preparation by individual apartment heating units. The rehabilitation activity consists in replacing the present pumping devices with new ones that feature functional characteristics that correspond to

the present and future requirements of the consumers. These new devices will exhibit technologies present today on the worldwide market.

2. Modernize the pumping station to ensure the increase of energy efficiency and economic efficiency of the domestic and industrial water supply activity, that is, introduce the process automation for a reduced specific consumption of electric energy and reduced operational workforce.

To solve the optimization problem, the authors developed a general mathematical model that will emphasize the importance of the relationship between energy side and technological side of the analyzed process.

The calculation of the ensemble's overall output formed by the pumping station, the distribution network, consumers, loads into consideration the charge specific features which correspond to each ensemble's element, for the two work phases of hydrophore: fill up and emptying. It will correspond in (Q, H) plane by one specific feature of the network – consumer ensemble, for each combination (number, type, position) of active consumers.

It heads into consideration the head equal specific feature H_R, (H_D - head in pipes network origin; Q_D - flow in network origin; Q_R - network flow; α_n - heading grade on network):

$$H_{\mathrm{R}} = \frac{H_{\mathrm{D}} \cdot Q_{\mathrm{R}}^2}{\alpha_n^2 \cdot Q_{\mathrm{D}}^2};\ \alpha_n \in \left[0,\ 1\ \div\ 1\right]\ . \tag{1}$$

The hydrophore's head in the analyze section (O) in filling stage $H_{(O)u}$ is shown by the following mathematical relation, (H_{gH} - hydrophore geometrical head; H_H - hydrophore head; $M_{rH,u}$ - hydrophore resistance hydraulic modulus for filling; $Q_{H,u}$ - hydrophore flow for filling):

$$H_{\mathrm{(O),u}} = H_{\mathrm{gH}} + H_{\mathrm{H}} + M_{\mathrm{rH,u}}\ Q_{\mathrm{H,u}}^2\ , \tag{2}$$

compared to the water level from the pumping station's aspiration basin, in the analyze section O, for filling up and:

$$H_{\mathrm{(O),e}} = H_{\mathrm{gH}} + H_{\mathrm{H}} - M_{\mathrm{rH,e}}\ Q_{\mathrm{H,e}}^2 \tag{3}$$

for emptying, ($H_{(O),e}$ - hydrophore head in section O, emptying stage; $M_{rH,e}$ - hydrophore resistance hydraulic modulus for emptying; $Q_{H,e}$ - hydrophore flow for emptying). It was made a program of automatic calculation which can determinate the functional and energetic specific feature of hydraulic machines, for ordinary speed n and nominal speed n_o. The charge specific feature of the pumps can be designed as parabola with completely equation, or as parabola with incompletely equation, (H - pump head; H_{pf} - pump head; k_{pf} - pumps resistance hydraulic modulus) [7]:

$$H = H_{\mathrm{o}} + H_1 .\ Q + H_2 .\ Q^2\ ,\quad H = H_{\mathrm{pf}} - k_{\mathrm{pf}} .\ Q^2\ . \tag{4}$$

The gap between the flow delivered by a pump with discontinuous running and the one the network is really supplying (keeping head H in the range that ensures the prescribed quality of the supply), compensation capacity has to allow the creation - between the minimal level, corresponding to the necessary pressure which keeps the minimal head requested by the network H_m, and the maximal level H_M, which is accepted through technical and energetic criteria and ensures the maximal superior limit head on the recommended operating range: $H_M = H_m + \Delta H$ of a serviceable water volume V_u. This value is calculated from the condition that imposes that, compared to the average pump flow Q_{pm} - on the recommended field (H_m, H_M), duration of the filling-emptying cycle T_c - between two successive pump start-ups - to be at least equal with a minimal admitted time T_e, which is specific to the chosen electric drive:

$$V_{\mathrm{u}} \geq \frac{Q_{\mathrm{pm}} . T_{\mathrm{c}}}{4}\,;\ T_{\mathrm{c}} \geq T_{\mathrm{e}}\,. \tag{5}$$

The outturn specific feature of the pump written as parabola with equation without free term, (R_1 and R_2 are parabola constants):

$$R_{\mathrm{p}} = R_1 . Q - R_2 .\ Q^2\ . \tag{6}$$

The program calculates the resistance hydraulic modulus for any pipe - line network, taking notice of all singularity types. The head specific feature for pumping station H_{PS} has the following mathematical form, (M_{ro} - pipes network resistance hydraulic modulus; p - pumps number; Q_{PS} - pumping station flow):

$$H_{\mathrm{PS}} = H_{\mathrm{pf}} - \frac{K_{\mathrm{pf}} + M_{\mathrm{ro}}}{p^2}\ Q_{\mathrm{PS}}^2, \tag{7}$$

The mathematical expressions that define the flow and the head for pumping station – networks – hydrophore filling stage ensemble, in O section are:

$$Q_{\mathrm{PS\text{-}R\text{-}H,f}} = \sqrt{\frac{H_{\mathrm{pf}} - H_{\mathrm{g,R\text{-}H,u}}}{M_{\mathrm{R\text{-}H,u}} + \dfrac{K_{\mathrm{pf}} + M_{\mathrm{ro}}}{p^2}}}, \quad H_{\mathrm{PS\text{-}R\text{-}H,u}} = H_{\mathrm{pf}} - \frac{H_{\mathrm{pf}} - H_{\mathrm{g,\,R\text{-}N}}}{\dfrac{M_{\mathrm{R\text{-}H,u}} \cdot p^2}{K_{\mathrm{pf}} + M_{\mathrm{ro}}} + 1}. \tag{8}$$

The power asked by network $N_{c,u}$ and the absorbed power by pump $N_{a,u}$ in the filling stage have the following mathematical relation:

$$N_{\mathrm{c,u}} = \gamma .\ Q_{\mathrm{PS-R-H,u}}\ . H_{\mathrm{(O),PS\text{-}R\text{-}H,u}}\ ;\ N_{\mathrm{a,u}} = \frac{\gamma . Q_{\mathrm{p,u}} . H_{\mathrm{p,u}} . p}{\eta_{\mathrm{p}} . \eta_{\mathrm{m}}}\,;\ Q_{\mathrm{p,u}} = \frac{Q_{\mathrm{PS-R-H,u}}}{p}\ . \tag{9}$$

The total outturn of pumping aggregate – networks – hydrophore fill – up stage ensemble has the following mathematical relation:

$$\eta_{\mathrm{u,PA}} = \frac{N_{c,f}}{N_{\mathrm{a,f}}} = \eta_{\mathrm{p}}\ \eta_{\mathrm{m}} . \frac{1}{1 + \dfrac{K_{\mathrm{pf}} + M_{\mathrm{ro}}}{p^2}\ \dfrac{Q_{\mathrm{PS\text{-}R\text{-}H,u}}^2}{H_{\mathrm{(O),PS\text{-}R\text{-}H,u}}}}. \tag{10}$$

The hydrophore is acting in the network like a generator and has the following flow, in the emptying stage:

$$Q_{\mathrm{H,g}} = \sqrt{\frac{H_{\mathrm{g,H}} + H_H - H_{(\mathrm{O})}}{M_{\mathrm{rH,g}}}}. \tag{11}$$

It can be written these relations in accordance with the continuity equation, for the O section in the emptying stage of hydrophore:

$$Q_{(\mathrm{O}),\mathrm{H\text{-}SP,g}} = Q_{(\mathrm{O}),\mathrm{H,g}} + Q_{(\mathrm{O}),\mathrm{PS}}. \tag{12}$$

The flow and the head for pumping station – networks – hydrophore emptying stage ensemble, in O section are:

$$Q_{\mathrm{PS\text{-}R\text{-}H,g}} = \sqrt{\frac{H_{\mathrm{PS\text{-}H,g}}}{M_{\mathrm{PS\text{-}H,g}} + M_{\mathrm{R}}}}\ ; \quad H_{(\mathrm{O}),\mathrm{PS\text{-}R\text{-}H,g}} = H_{\mathrm{PS\text{-}H,g}} \left(1 - \frac{1}{1 + \dfrac{M_{\mathrm{R}}}{M_{\mathrm{PS\text{-}H,g}}}} \right) \tag{13}$$

The powers asked by network and pump, in the emptying stage have the following mathematical forms:

$$N_{\mathrm{c,g}} = \gamma \cdot Q_{\mathrm{PS\text{-}R\text{-}H,g}} \cdot H_{(\mathrm{O}),\mathrm{PS-R-H,g}}\ ; N_{\mathrm{a,g}} = \frac{\gamma \cdot Q_{\mathrm{p,g}} \cdot H_{\mathrm{p,g}} \cdot p}{\eta_{\mathrm{m}} \cdot \eta_{\mathrm{p}}} ; Q_{\mathrm{p,g}} = \frac{Q_{\mathrm{PS-R-H,g}} - Q_{\mathrm{H,g}}}{p}. \tag{14}$$

The overall outturn of the pumping station – networks – hydrophore emptying stage ensemble, in O section has the following mathematical relation:

$$\eta_{\mathrm{g,PA}} = \frac{N_{\mathrm{c,g}}}{N_{\mathrm{a,g}}} = \frac{\eta_{\mathrm{m}}\ \eta_{\mathrm{p}}}{\left(1 - \dfrac{Q_{\mathrm{H,g}}}{Q_{(\mathrm{O}),\mathrm{PS\text{-}R\text{-}H,g}}} \right)} \cdot \frac{1}{\left[1 + \dfrac{k}{p^2\ H_{(\mathrm{O}),\mathrm{PS\text{-}R\text{-}H,g}}} \left(Q_{\mathrm{PS\text{-}R\text{-}H,g}} - Q_{\mathrm{H,g}} \right)^2 \right]} \tag{15}$$

The operational regimes for the pumping station supplies (ensemble of active pumps in the pumping station – open level tanks – slopes) will be analyzed taking into account required static heads, which vary in a pre-established range. This will emphasize the options to increase the designed flow rate, and determine energetic and economic characteristics of the typical operational regimes. One of the goals is to increase the transport capability of gravitational supplies. Energy employed to transport the fluid unit weight in the network unit length is given by the hydraulic head J_o – a parameter that influences every energetic and economic characteristic of the water transport and distribution ensemble pumping station – pipe network – consumer, $J_o = m.Q^{\gamma}.D^{-\beta}$. H_{t} represents the head loss in the discharge pipe for the pipe material, $H_t = m.L.Q^{\gamma}.D^{-\beta}$. To cover for the head losses in water transport of the annual volume W_o that is absorbed from the supply source [5], the energy required E'_p is:

$$E_p^{'} = F.E_p;\ E_p = \frac{W_o.H_o}{367.\eta_h.\eta_a} + \frac{1}{367}.\sum_{i=1}^{n}\frac{W_i.H_i}{\eta_h^i.\eta_a^i}\ ; \tag{16}$$

Constant F is calculated with the form, (f, g - specific parameter; $p(q_i)$ - relative flow frequency; q_i - relative flow; β, γ - constant of hydraulic slope):

$$F = f^{-1}.g;\ f = \sum_i q_i . p(q_i);\ g = \sum_i\ q_i^{\gamma+1}\ .p(q_i) \tag{17}$$

The investment in constructions and devices I_p for pressurized transport is, (I_{Po} - investment in pumping station; i_p - investment coefficient in constructions and installations):

$$I_p = I_{po} + i_p\ .\ N_i\ . \tag{18}$$

Processing the data acquired on the dependence between the investment in pipes I_R and the rated diameter D it follows that, (i_o - coefficient investment in pipe network; L - pipe length; n_N - upsetting pipe number; b - constant):

$$I_R = n_N\ .\ L.\ \left(i_o + b\ .\ D^{\alpha}\right)\ . \tag{19}$$

The unitary cost of power energy p_o is different in the vertex period of head curve against basis period [2], (p_b - basis energy unitary cost; p_v - vertex energy unitary cost; t_p - pumping daily average time; t_{vp} - pumping daily average time in vertex period):

$$p_o = p_b\ .\ \left[1 + \nu_p\ .\ \left(m_v - 1\right)\right]\ ;\ \nu_p = \frac{t_{vp}}{t_p};\ m_v = \frac{p_v}{p_b}. \tag{20}$$

The yearly average expenses quota in pumping station a_P'' and the yearly average expenses quota in discharge pipe a_R'' take into account different development rates for various economic domains that affect this analysis and all expenses are computed relative to the same moment in time: the first day of operation [2], (a_p - average overall quota in pumping station; a_r - average overall quota in pipe; r - monthly average rate for updating; t - recovery time of investment; T_r - existence standardised duration for the analysed system; u_a - annual average increase instalment; u_c - average parameter of cost annual increase; u_e - actualisation coefficient):

$$a_p^{''} = a_p^{'} + \frac{1}{T_r},\ a_p^{'} = a_p.\frac{\sum_{k=1}^{t}\left(\frac{1+u_a}{1+r}\right)^k}{\sum_{k=1}^{t}\left(\frac{1+u_e}{1+r}\right)^k},\ T_r = \sum_{k=1}^{t}\left(\frac{1+u_e}{1+r}\right)^k. \tag{21}$$

$$a_R^{''} = a_R^{'} + \frac{1}{T_r};\ a_R^{'} = a_R\ \frac{\sum_{k=1}^{t}\left(\frac{1+u_c}{1+r}\right)^k}{\sum_{k=1}^{t}\left(\frac{1+u_e}{1+r}\right)^k} \tag{22}$$

The energy unitary specific consumption e_s depend of flow $Q_{H,u}$, head hydraulic power $H_{H,u}$ and outturn $\eta_{H,u}$ corresponding to mathematical relation:

$$e_{\mathrm{s}} = \frac{N_{\mathrm{H,u}} \cdot 10^3}{3600 \cdot \eta_{\mathrm{H,u}} \cdot Q_{\mathrm{H,u}} \cdot H_{\mathrm{H,u}}}. \tag{23}$$

The optimization problem consists in identification of the proper values for pumping station operational parameters that will determine the minimum specific consumption averaged on yearly basis, abiding by the operational and constructional restrictions as well as assuming normalized section dimensions; some of these variables (D, L, n, η) have direct or indirect influences on device's proper operation [3]. The goal is to determine the values of the D, L, n parameters that minimize the economic target function $Z(D, n)$. This function is given by the equation (24):

$$Z = a''_{\mathrm{p}} \cdot I_{\mathrm{p}} + a''_{\mathrm{R}} \cdot I_{\mathrm{R}} + p_{\mathrm{o}} \cdot E_{\mathrm{p}} = a''_{\mathrm{p}} \cdot \left(I_{\mathrm{po}} + i_{\mathrm{p}} \cdot m \cdot \frac{k \cdot Q_{\mathrm{M}}^{\gamma+1} \cdot L}{\eta_{\mathrm{PA}} \cdot n_{\mathrm{N}}^{\gamma} \cdot D^{\beta}} \right) + a''_{\mathrm{R}} \cdot n_{\mathrm{N}} \cdot L \cdot \left(i_{\mathrm{o}} + b \cdot D^{\alpha} \right) + \frac{k.m.L.Q_{\mathrm{M}}^{\gamma} . F.W_{\mathrm{o}} . p_{\mathrm{o}}}{D^{\beta} . n_{\mathrm{N}}^{\gamma} . \eta . 3600}. \tag{24}$$

The solution for the pair of variables (D, n) is given by the values that minimize the economic target function $Z(D, n)$; mathematically this means:

$$\frac{\partial Z}{\partial n} = 0; \frac{\partial Z}{\partial D} = 0 \tag{25}$$

The mathematical formulae for the optimum number of discharge pipes and for the optimum pipe diameter are:

$$n_{\mathrm{o}} = \left[\left(\frac{\alpha.\gamma}{\beta} - 1 \right) . \frac{b^{\beta}}{i_{\mathrm{o}}^{\alpha+\beta}} \right]^{\frac{1}{\alpha.(\gamma+1)}} . \left[\frac{k.m.\beta}{a''_{\mathrm{R}} . \alpha . \eta} . \left(i_{\mathrm{p}} . Q_{\mathrm{M}}^{\gamma+1} . a''_{\mathrm{p}} + \frac{Q_{\mathrm{M}} . F.W_{\mathrm{o}} . p_{\mathrm{o}}}{3600} \right) \right]^{\frac{1}{\gamma+1}};$$
$$D_{\mathrm{o}} = \left[\frac{k.m.\beta}{b.\alpha.\eta^{\gamma+1} . a''_{R}} . \left(a''_{\mathrm{p}} . i_{o} . Q_{\mathrm{M}}^{\gamma+1} + \frac{Q_{\mathrm{M}} . F.W_{\mathrm{o}} . p_{\mathrm{o}}}{3600} \right) \right]^{\frac{1}{\alpha+\beta}}. \tag{26}$$

The optimum pump type and dimensions (number of stages and rotational speed) is determined such as it may ensure the required flow rate, with specified head, for the highest value of efficiency; this value will become the reference maximum efficiency for pump selection.

For a given water supply system, with specified operational capacity, the same mathematical model is used, but this time the nominal diameter of the discharge pipe is known; it is possible to calculate an optimal flow Q_{opt} and then (with imposed conditions) the minimal annual average total cost. Then, comparing with the required supply capacity and analyzing previous data, the measures for modernizing and improving the studied water supply system may be chosen.

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To make the best selection of a pump, it is useful to determine maximal efficiencies that can be reached by pumps having $z = 1, 2, ..., k^*$ stages, which, drive at different synchronism speeds, and may ensure the requested (Q, H) parameters. This is the method used to establish all functional and constructive pump characteristics and, also, the energetic performances required.

The selected pumps need match the required variables imposed by the water transport supply network. To reach this goal, pumps may be operated intermittently, or required flow rates may be compensated with a supplemental tank, that may be free level tank or air cushion tank (booster) that keeps constant operational pressure, ensuring also the network surge protection [6].

Efficiency of this control method is conditioned by satisfying the network requirements, maintaining the pump efficiencies in the neighbourhood of their maximal efficiency. Efficiency may be maintained at high levels if pump is properly sized and the compensation capacity is adequate. Also, it is mandatory to adequately operate the system composed of pumps, tank and network.

3 Experimental results

The optimization method is applied in the pumping station Codrescu, Iasi, for drinkable water, Figure 1. The pumping station is equipped with EP NK 64 x 4 pumps and rotational speed of n = 2900 rpm. Using several original mathematical algorithms, authors developed a computer program that calculates the functional parameters of the ensemble pumping station – hydrophore – pipe distribution network, as well as the available consumer parameters [4]. This may be accomplished at each moment in time, depending on the number of active consumers simultaneously connected to the supply network, in the hypothesis of a minimum price of cubic meter of pumped water.

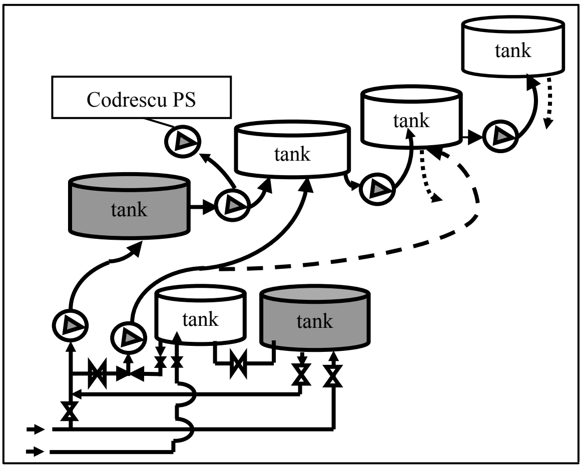

Figure 1: The drinkable water supply system scheme of Iasi city with Codrescu pumping station.

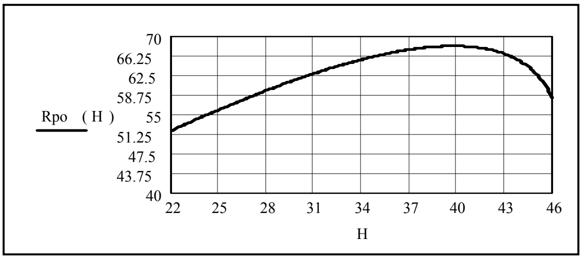

Figure 2: Nominal outturn variation R_{po} in accordance with head H for EP NK 64x4 pump.

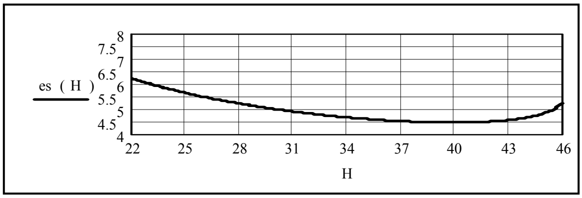

Figure 3: Unitary specific energy consumption variation e_s depending on head H, after the system's optimization.

Figure 2 shows the variation of outturn in accordance with pump's head $R_{po}(H)$.

The unitary specific energy consumption $e_s(H)$ for EP NK 64x4 pump depending on head, after the system's optimization are presented in Figure 3. The energy specific consumption e_s depend on the energy consumed in the period reference and water volume delivered in same period.

Figure 4 shows the working regimes of Codrescu pumping station at hydrophore heads H_H = 15 m, after the system's optimization. It is drawn outturn curves for $R_{H,u}$ = 50 ÷ 68%; also are drawn the variations of flow $Q_{H,u}$, head $H_{H,u}$, hydraulic power $N_{H,u}$ and unitary specific energy consumption variation e_s for different static head on hydrophore H_H at filling stage. The flow, power and unitary specific energy consumption variation depending on the hydrophore head, in filling stage, after the system's optimization are shown in Figure 5.

Codrescu pumping station working on hydrophore and outturn depending on flow Q, after system optimizations are presented in Figure 6. The recovery time of investment for the rehabilitation of Codrescu pumping station depend on the pumped water volume W_o and the monthly instalments number of credit engaged for the rehabilitation's achievement.

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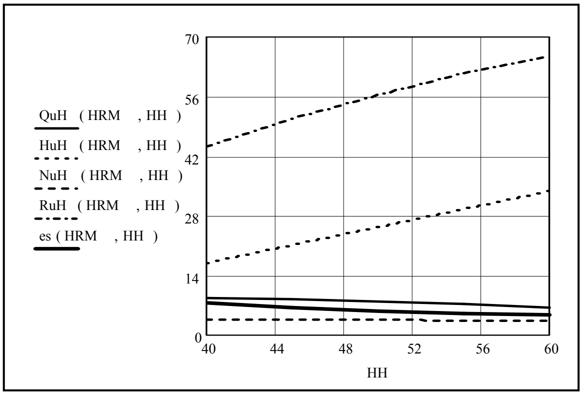

Figure 4: The working regimes of Codrescu pumping station with hydrophore head H_H = 15 m, at filling stage, after the system's optimization.

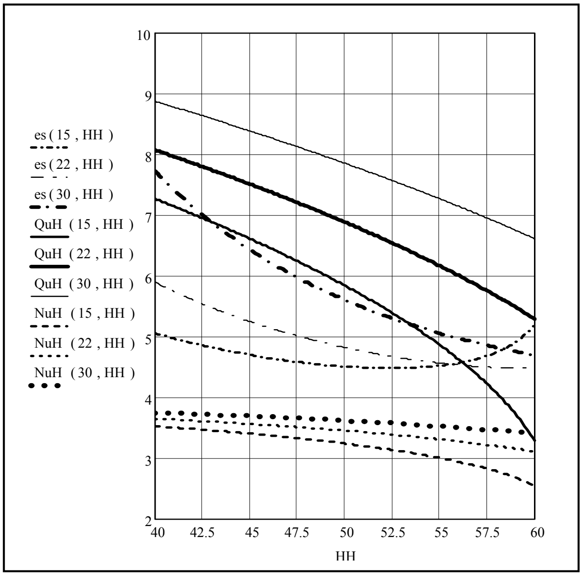

Figure 5: Flow, power and unitary specific energy consumption depending on hydrophore head, in filling stage, after the system's optimization.

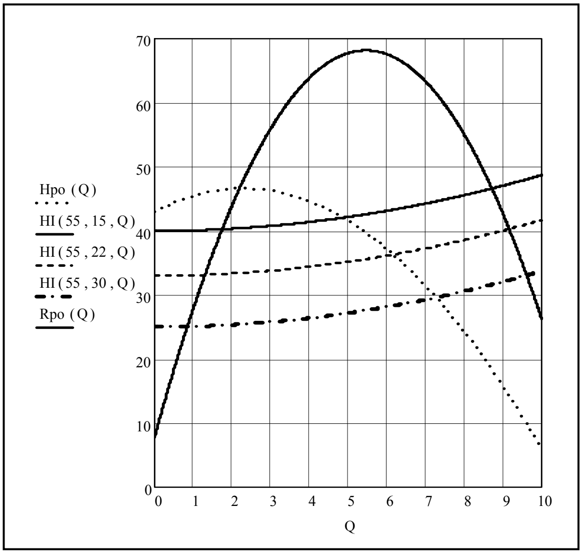

Figure 6: Codrescu pumping station working on hydrophore and outturn depending on flow *Q,* after the system's optimization.

4 Conclusions

The replacement of the existent equipment, that is obsolete from physical and technological point of view, must be done with new equipments with performances that will meet the requirements of an optimum operation from both energetic and economic perspectives. The water transport and distribution network must have the capability to meet the requirements of the consumers.

The insurance of efficient operation relies on automatic supervision and control of pumping installation, as well as automatic adjustments to variable consumer requirements.

The proposed analysis method is based on the system's mathematical modelling, simplified by analytic specific features of its components and the automated data processing system.

This analysis method has two objectives: the determination of the overall output about the pumping station – network – hydrophore – consumer's ensemble and the consumer's total typical energy e_s. The analyse was done to define the regimes of exploitation thus the overall output of the installation to be maximum, and the consumption of total specific energy to be minimum on the entire working cycle. Those two distinctive fazes of the hydrophore function (filling in/emptying) have been analysed depending on the loading grade of the network, α = (0,1 ÷ 1). The hydraulic system works with the following parameters: head H = (43 ÷ 73) m, flow Q = (5 ÷ 7,3) m^3/s, e_s = (4,5 ÷ 6,25) kWh/m^3, η = (63 ÷ 68)%; these parameters are imposed by analysing with this method, through application of the software made by author.

If the consumers want to have a better water supplying regime (head H, flow Q and outturn η), the better parameters cannot be realised without increasing the total specific energy: meaning that the price of the water will grow up as well.

The research results are used for design optimization of the water supply installation for areas with various relief forms. The proposed method for energetic optimization allows a reduction with 10 ÷ 15% of the energy consumption required to operate the pumping station – network – hydrophore – consumers ensemble.

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