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Contribution as for the Optimization of the Pumping Stations

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Summary

The paper follows the analyse of the connections between the constructive, working parameters, the annual energy consumptions and the energy quantity included in fitting out; it will formulate a methodology of establishment of the optimum values of the parameters of admeasurements of the pumping stations for the setting under pressure, of pipes networks, what ensure an optimum consumption of energy during of duty of the fitting out (the operational energy and the included energy in the networks, equipment and constructions), of the conditions after that it can be obtained. It will follow the generalization of the solutions of increase of the power and economic efficiency of the water's pumping, what will ensure the minimum of the total consumption of energy necessary for the networks under pressure, in the conditions of the respect of the restrictions imposed by the complex climate – ground – plant technique.

keywords: Pumping station, pipe network, economic efficiency, optimization, optimum piezometer slope.

Introduction

The paper follows the perfecting of the model of optimisation SPP through to take the factors what determine the process of irrigation into consideration:

- The static characteristics of the variation of the water need of the complex plant – ground;
- The variation of the debit of admeasurements in long of the feelers, depending on the equipment of wetting used and the geometry in plan of plot.
- The form of the irrigated field of a feeler and of the plot.

The model of optimum admeasurements of pumping station under pressure through pipes under pressure is elaborated for plan ground and in slope, in any conditions of water need and taking the equip possibilities into account offered by the present technique:

1. The diameter of the aspersion nozzles;
2. The distance between sprinklers on wing;
3. The diameter of the aspersion wing;
4. The diameter of pipes and the installation's debit;
5. The diameter of the pipes used for the realization of the feelers;

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6. The diameter of the pipes superior order;
7. The charge necessary at hydrant proper of the pressure demanded of the correct working of the installations of aspersion;
8. The consumption of energy generated by the equipment's removal wetting is estimated for the case of the pulled installations and manual displaced.

Objective function

The results of researches serve at the optimum designing of point of view energetic of the fittings out for irrigations in the zones with plan relief and in steep, the methods proposed allow a reduction with 20 $\div$ 25 % of the consumption of energy generated by the irrigation through aspersion.

The paper tackle the working of a pumping station with pipes under pressure on the basis of analyse of the connections between the constructive and working parameters, of the energy included in fitting out and of the operative consumption of energy (for water's pumping, the remove wet equipment, the maintenance and exploitation of working) on rate-setting duration of existence of system.

The optimisation problem matters in the minimization of the specific consumption total average annual of energy demanded by irrigation through pipes under pressure of the complex climate – ground – plant. The needs of water is expressed through a average norm of irrigation M (mm/year), a specific debit of top q_d (l/s) and the static features of the annual variation and seasonal q/q_d, respectively $(q/q_d)^2$, in the conditions of the respect of the functional restrictions and of the limitation introduced by the technique of irrigation available.

For the solution of the optimization problem is elaborated a general mathematical model, which ensure the connection between the power and technological side of the process analysed. The conditions are the following:

1. The optimum structure of the wet installations through aspersion and the functional features: $d, n_{as}, H_{na}, Q_{ar}$.
2. The optimum structure of the fix network of pipes under pressure associated of a area S give: L_{cs}, L_{cp}, n, L.
3. The diameters what will be used in the realization of the fix network's elements and the lengths of the pipes; it will estimate the optimum consumption of energy in ensemble E_1, and on components: $(I_{1R}, I_{1SP}, I_{1IU}, E_{it}, E_{1H}, E_{1M})$.
4. The optimum piezometer slope proper to the debit of admeasurements, J_o and the parameters of pumping station under pressure (Q, H).

The optimization specific consumption of energy is assessed depending on the stud's size S and the features of water consumption: M_o, q_d, (q/q_d), $(q/q_d)^2$.

The optimization model will be applied at the optimum admeasurements of rectangular studs for irrigation through aspersion, respective for the irrigation –

in the same conditions of water need – through EUBA installations, analysing the influence to the restrictions considered acceptable concerning of the technical features and of the specific consumption energy.

The optimization model will be applied at the optimum admeasurements of rectangular studs for irrigation through aspersion and EUBA installations, analysing the influence to the restrictions concerning of the technical features and of the specific consumption energy.

The specific consumption total medium yearly of energy

The specific consumption total medium yearly of energy result of the summing of the specific consumption medium yearly associated to the energy included:

$$E^1 = \frac{I_{sp}^1}{T_{sp}^1} + \frac{I_R^1}{T_R} + \frac{I_{IU}^1}{T_{IU}} + a_R I_R^1 + a_{SP} I_{SP}^1 + a_{IU} I_{IU}^1 + (1+k_{re})\bar{E}_p^1 + \bar{E}_M^1, \qquad (1)$$

respective:

$$E^1 = a_{_{SP}}^1 I_{SP}^1 + a_{_R}^1 I_R^1 + a_{_{IU}}^1 I_{IU}^1 + (1+k_{re})\bar{E}_p^1 + \bar{E}_M^1, \left(\frac{kWh}{ha \cdot year}\right), \qquad (2)$$

with:

$$a_j^1 = a_j + \frac{1}{T_j}, \qquad (3)$$

T_j – the duration normalized of existence j component. The specific consumption total medium yearly of energy has this shape:

$$\begin{aligned} E_1 = & \frac{5000 a_{SP}^1 I_{SP0} l}{k_S n L^2} + a_{SP}^1 \frac{K_I K_N}{\eta_{SP}} q_d (H_g + H_H + H_t) + a_{IU}^1 \frac{q_d}{Q_{IU}} (I_{IU} + i_{IU} L) + \frac{5000 a_R^1}{nL} \\ & \cdot \left\{ [l(n-1) + (n-2)]\, i_0 + a[(n-1)\, l \varphi(n) + n \psi(n)] \frac{K_I^{\frac{\alpha}{\beta}} (n_t Q_{IU})^{\frac{\alpha\gamma}{\beta}}}{I_0^{\frac{\alpha}{\beta}}} \right\} \\ & + (1+k_{re}) \frac{K_N}{k_m} q_d H_t \overline{\left(\frac{q}{q_d}\right)^2} T_0 + (1+k_{re}) \frac{K_N}{k_m} q_d \cdot (H_g + H_H) \overline{\left(\frac{q}{q_d}\right)} T_0 \\ & + \frac{M_0}{m_0} \frac{C_M}{l_{IU}} \frac{10^4}{L}, \left(\frac{kWh}{ha \cdot year}\right). \end{aligned} \qquad (4)$$

The charge utilised for transport is expressed through:

$$H_t = J_0 L \frac{(n-1)\, l + 1}{l}, \qquad (5)$$

while the charge at hydrant is establish of:

$$H_H = H_0 + h_{rIU}; \tag{6}$$

h_{rIU} represent the lossof charge on the instalation of wetting:

$$h_{rIU} = k_{hr} Q^{\beta_H L}, \tag{7}$$

for the instalations with debit independent and:

$$h_{rIU} = \frac{k_{hr}}{k_p} d^{\beta_H} L^{\gamma_H}, \tag{8}$$

in the case of aspersion, with k_{hr}, β_H, γ_H – empiric coefficients adequate to the equipments used. I have note:

$$Y = 1 + \frac{1+k_{re}}{a^1_{SP} k_m K_1} \overline{\left(\frac{q}{q_d}\right)^2} T_0; \quad Y_1 = 1 + \frac{1+k_{re}}{a^1_{SP} k_m K_1} \overline{\left(\frac{q}{q_d}\right)} T_0. \tag{9}$$

The specific consumption total medium yearly of energy E^1 becomes:

$$\begin{aligned} E^1 = & \frac{5000 a^1_{SP} I_{SP0}}{k_s} \frac{l}{nL^2} + 5000 a^1_R i_0 \frac{(n-1)\,l + n - 2}{nL} \\ & + a^1_{IU} I_{IU0} \frac{q_d}{Q_{IU}} + a^1_{IU} i_{IU} \frac{q_d}{Q_{IU}} L + \frac{M_0}{m_0} \frac{C_M}{l_{IU}} \frac{10^4}{L} \\ & + a^1_{SP} K_1 K_N \frac{Y_1}{\eta_{SP}} q_d H_g + a^1_{SP} K_1 K_N \frac{Y_1}{\eta_{SP}} q_d H_0 \\ & + a^1_{SP} K_1 K_N \frac{Y_1}{\eta_{SP}} q_d h_{rIU} + a^1_{SP} K_1 K_N \frac{Y}{\eta_{SP}} q_d \frac{(n-1)\,l + 1}{l} L J_0 \\ & + 5000 a a^1_R \frac{(n-1)\,l \varphi(n) + n \psi(n)}{nL} K_J^{\frac{\alpha}{\beta}} \frac{(n_t Q_{IU})^{\frac{\alpha\gamma}{\beta}}}{J_0^{\frac{\alpha}{\beta}}}. \end{aligned} \tag{10}$$

The optimum consumption of energy

The equation (10) can be writed in the shape of (the function E^1_J is minimized in raport with piezometer slope J_o and the function E^1_{0J} is independent of J_0):

$$E^1 = E^1_{0J} + E^1_J, \tag{11}$$

with

$$E^1_J = a^1_{SP} K_I K_N \frac{Y}{\eta_{SP}} \frac{(n-1)\,l + 1}{l} L q_d \left(J_0 + \frac{X_J}{J_0^{\frac{\alpha}{\beta}}} \right) \tag{12}$$

and

$$X_J = \frac{5000l}{L^2 q_d} \frac{l\,(n-1)\,\varphi\,(n) + n\psi\,(n)}{n\,[(n-1)\,l+1]} \frac{K_J^{\frac{\alpha}{\beta}}}{K_N \frac{K_I}{a} \frac{a_{SP}^1}{a_R^1}} \cdot \frac{(n_t Q_{IU})^{\frac{\alpha\gamma}{\beta}}}{\frac{Y}{\eta_{SP}}} \tag{13}$$

and

$$\begin{aligned} E_{0J}^1 = & \frac{5000 a_{SP}^1 I_{SP}}{k_S} \frac{l}{nL^2} + 5000 a_R^1 i_0 \frac{(n-1)\,l+n-2}{nL} \\ & + a_{IU}^1 I_{IU0} \frac{q_d}{Q_{IU}} + a_{IU}^1 i_{IU} \frac{q_d}{Q_{IU}} L + \frac{M_0}{m_0} \frac{C_M}{l_{IU}} \frac{10^4}{L} \\ & + a_{SP}^1 K_1 K_N \frac{Y_1}{\eta_{SP}} q_d H_g + a_{SP}^1 K_1 K_N \frac{Y_1}{\eta_{SP}} q_d H_0 \\ & + a_{SP}^1 K_1 K_N \frac{Y_1}{\eta_{SP}} q_d h_{rIU}. \end{aligned} \tag{14}$$

The piezometer slope is expressed depending on the debit Q of wetting installation:

$$\begin{aligned} J_0^* = & \left[\frac{l\,(n-1)\,\varphi\,(n) + n\psi\,(n)}{n\,[(n-1)\,l+1]}\right]^{\frac{\beta}{\alpha+\beta}} \\ & \cdot \frac{K_J^{\frac{\alpha}{\alpha+\beta}}}{\left(K_N \frac{K_I}{a} \frac{a_{SP}^1}{a_R^1} \frac{\beta}{\alpha}\right)^{\frac{\beta}{\alpha+\beta}}} \frac{1}{\left(\frac{Y}{\eta_{SP}}\right)^{\frac{\beta}{\alpha+\beta}}} \left(\frac{5000l}{L^2 q_d}\right)^{\frac{\beta-\alpha\gamma}{\alpha+\beta}}. \end{aligned} \tag{15}$$

respective, depending on the length l and the specific debit of admeasurement:

$$\begin{aligned} J_0^* = & \left[\frac{l\,(n-1)\,\varphi\,(n) + n\psi\,(n)}{n\,[(n-1)\,l+1]}\right]^{\frac{\beta}{\alpha+\beta}} \\ & \cdot \frac{K_J^{\frac{\alpha}{\alpha+\beta}}}{\left(K_N \frac{K_I}{a} \frac{a_{SP}^1}{a_R^1} \frac{\beta}{\alpha}\right)^{\frac{\beta}{\alpha+\beta}}} \frac{1}{\left(\frac{Y}{\eta_{SP}}\right)^{\frac{\beta}{\alpha+\beta}}} \left(\frac{5000l}{L^2 q_d}\right)^{\frac{\beta-\alpha\gamma}{\alpha+\beta}} \end{aligned} \tag{16}$$

The equation (16) shows the relation between the optimum unitary specific consumption of energy for the transport of the debit of dimensioning through fixed network and every factors what it conditions (the specific features of the water consumption for irrigation: q_d, Y; the network's geometry: n, l, L; the pipe's specific features used: K_J, β, γ, a, α, a_R^1; the specific features of pumping: K_N, K_I, η_{SP}, a_{SP}^1).

The component dependent on J_0 of specific consumption total medium yearly of energy is:

$$E_J^1 = f_j \frac{aa_R^1}{L} \left[\frac{l(n-1)\varphi(n) + n\psi(n)}{n[l(n-1)+1]} \right]^{\frac{\beta}{\alpha+\beta}} \left[\frac{l(n-1)+1}{l} \right] \cdot \left(1+\frac{\alpha}{\beta}\right) \left(K_J K_N \frac{K_I}{a} \frac{a_{SP}^1}{a_E^1} \frac{\beta}{\alpha} \frac{Y}{\eta_{SP}} \right)^{\frac{\alpha}{\alpha+\beta}} (5000l)^{\frac{\beta-\alpha\gamma}{\alpha+\beta}} \cdot \left(L^2 q_d\right)^{\frac{\beta-\alpha\gamma}{\alpha+\beta}}. \quad (17)$$

In the general event:

$$E_J^1 = f_J K_{E_J}^{(Q)} \left(\frac{Y}{\eta_{SP}}\right)^{\frac{\alpha}{\alpha+\beta}} q_d^{\delta_{E_J}} \frac{n^{\alpha_{E_J}}}{l^{\beta E_J}} L^{\lambda E_Q} Q_{IU}^{\gamma_{E_J}}, \quad (18)$$

but in the case of aspersion:

$$E_J^1 = f_J K_{E_J}^{(d)} \left(\frac{Y}{\eta_{SP}}\right)^{\frac{\alpha}{\alpha+\beta}} q_d^{\delta_{E_J}} \frac{k_{IU}^{\gamma_{E_J}}}{K_p^{\frac{\gamma_{E_J}}{2}}} \frac{n^{\alpha_{E_J}}}{l^{\beta_{E_J}}} \cdot L^{\lambda_{E_d}} d^{\beta_Q \gamma_{E_J}}. \quad (19)$$

The optimum consumption of energy depending on debit Q (Q independing on L)

The optimum consumption of energy, with debit Q independent on length L is:

$$E_Q^1 = f_J^{\frac{1}{1+\beta_{E_J}}} f_l K_{E_l}^{(Q)} f_Q \left(\frac{a_{SP}^1 I_{SP0} c_k}{k_s}\right)^{\frac{\beta_{E_J}}{1+\beta_{E_J}}} \cdot \left(\frac{Y}{\eta_{SP}}\right)^{\frac{\alpha}{(\alpha+\beta)\left(1+\beta_{E_J}\right)}} n^{\frac{\alpha_{E_J}-\beta_{E_J}}{1+\beta_{E_J}}} q_d^{\frac{\delta_{E_J}}{1+\beta_{E_J}}} Q_0^{\frac{\gamma_{E_J}}{1+\beta_{E_J}}} + a_{IU} I_{IU_0} \frac{q_d}{Q_0} + f_L 200 \sqrt{a_{IU} i_{IU}} \sqrt{\frac{M_0}{m_0} \frac{C_M}{l_{IU}}} \cdot \sqrt{\frac{1 + K_N \frac{a_{SP}^1}{a_{IU}^1} \frac{K_I}{i_{IU}} \frac{Y}{\eta_{SP}} k_{hr} Q_0^{\beta_H+1}}{Q_0}} \sqrt{q_d}. \quad (20)$$

Through the convenient grouping of terms and the numerical processing, for successions of values of the parametersQ_0, Z_1, Z_2, on the domain used in practice, it deducts the relation (20) in the shape of:

$$E_Q^1 = f_J^{\frac{1}{1+\beta_{E_J}}} f_l K_{E_l}^{(Q)} L_Q \left(\frac{a_{SP}^1 I_{SP_0} c_k}{k_s}\right)^{\frac{\beta_{E_J}}{1+\beta_{E_J}}} \left(\frac{Y}{\eta_{SP}}\right)^{\frac{\alpha}{(\alpha+\beta)\left(1+\beta_{E_J}\right)}} n^{\frac{\alpha_{E_J}-\beta_{E_J}}{1+\beta_{E_J}}} q_d^{\frac{\delta_{E_J}}{1+\beta_{E_J}}} \cdot \left(Q_0^{\frac{\gamma_{E_J}}{1+\beta_{E_J}}} + \frac{X_Q}{Q_0^{\beta`\psi}} \right), \quad (21)$$

with:

$$\frac{1}{Q_0} + \frac{Z_2}{Q_0^{\beta\phi}} = K'_{\psi} \frac{Z_2^{\gamma'_{\psi}}}{Q_0^{\beta'_{\psi}}}, \tag{22}$$

thus:

$$X_Q = \frac{f_L^{\gamma'_{\psi}}}{f_J^{\frac{1}{1+\beta_{E_J}}} f_l} K_{X_Q} \left(\frac{M_0}{m_0} \frac{C_M}{l_{IU}} \right)^{\frac{\gamma'_{\psi}}{2}} \cdot \frac{\left(\frac{Y_1}{\eta_{SP}} \right)^{\gamma'_{\phi} \gamma'_{\varphi}} q_d^{1-\frac{\gamma'_{\psi}}{2}-\frac{\delta_{E_J}}{1+\beta_{E_J}}}}{\left(\frac{Y}{\eta_{SP}} \right)^{\frac{\alpha}{(\alpha+\beta)\left(1+\beta_{E_J}\right)}} n^{\frac{\alpha_{E_J}-\beta_{E_J}}{1+\beta_{E_J}}}} k_s^{\frac{\beta_{E_J}}{1+\beta_{E_J}}} \tag{23}$$

with:

$$K_{X_Q} = \frac{K'_{\psi} \left(200 K'_{\phi} \right)^{\gamma'_{\psi}} k_{hr}^{\gamma'_{\phi} \gamma'_{\psi}}}{K_{E_l}^{(Q)} L_Q} \left(\frac{1}{a_{SP}^1 I_{SP_0} c_k} \right)^{\frac{\beta}{1+\beta_{E_J}}} \cdot \left(a_{IU}^1 I_{SP_0} \right)^{1-\gamma'_{\psi}} \left(a_{IU}^1 i_{IU} \right)^{\gamma'_{\psi}\left(0,5-\gamma'_{\phi}\right)} \left(a_{SP}^1 K_I K_N \right)^{\gamma'_{\phi} \gamma'_{\psi}} \tag{24}$$

It notes:

$$\begin{aligned} \nu_0 &= \frac{1}{\beta'_{\psi} + \lambda}; \\ \nu_1 &= \left(0,5\gamma'_{\psi} + \frac{\delta_{E_J}}{1+\beta_{E_J}} - 1 \right) \nu_0; \\ \nu_2 &= \nu_0 \left[1 - \gamma'_{\psi} \left(0,5 + \gamma'_{\phi} \right) \right]; \\ \nu_3 &= \nu_0 \gamma'_{\psi} \left(0,5 - \gamma'_{\phi} \right). \end{aligned} \tag{25}$$

The optimum debit of installation of wetting is calculated with following formula:

$$Q_0^* = \frac{f_L^{\nu_0 \gamma'_{\psi}}}{f_J^{\frac{\nu_0}{1+\beta_{E_J}}} f_l^{\nu_0}} K_{Q_0} \frac{k_s^{\frac{\beta_{E_J} \nu_0}{1+\beta_{E_J}}}}{n^{\frac{\alpha_{E_J}-\beta_{E_J}}{1+\beta_{E_J}} \nu_0}} \cdot \frac{\left(\frac{Y_1}{\eta_{SP}} \right)^{\nu_0 \gamma'_{\phi} \gamma'_{\psi}}}{\left(\frac{Y}{\eta_{SP}} \right)^{\frac{\nu_0 \alpha}{(\alpha+\beta)\left(1+\beta_{E_J}\right)}}} \frac{\left(\frac{M_0}{m_0} \frac{C_M}{l_{IU}} \right)^{0,5 \nu_0 \gamma'_{\psi}}}{q_d^{\nu_1}} \tag{26}$$

with:

$$K_{Q_0} = \left(\frac{\beta'_{\psi}}{\lambda} \right)^{\nu_0} \left(\frac{K'_{\psi} \left(200 K'_{\phi} \right)^{\gamma'_{\psi}} k_{hr}^{\gamma'_{\phi} \gamma'_{\psi}}}{K_{E_J}^{(Q)} L_Q} \right)^{\nu_0} \cdot \frac{\left(a_{SP}^1 K_I K_N \right)^{\nu_0 \gamma'_{\phi} \gamma'_{\psi}}}{\left(a_{SP}^1 I_{SP_0} c_k \right)^{\frac{\beta_{E_J} \nu_0}{1+\beta_{E_J}}}} \left(a_{IU}^1 \right)^{\nu_2} I_{IU_0}^{\nu_0\left(1-\gamma'_{\psi}\right)} i_{IU}^{\nu_3}. \tag{27}$$

It results:

$$
\begin{aligned}
E^1 = & a_{SP}^1 K_I K_N \frac{Y_1}{\eta_{SP}} q_d \left(H_g + H_0\right) + f_J^{\frac{1-\nu_0'}{1+\beta_{E_J}}} f_l^{1-\nu_0'} f_L^{\gamma_\phi' \gamma_\psi'} \\
& \cdot f_Q K_{E_Q} \frac{n^{\frac{\alpha_{E_J}-\beta_{E_J}}{1+\beta_{E_J}}\left(1-\nu_0'\right)}}{k_s^{\frac{\beta_{E_J}}{1+\beta_{E_J}}\left(1-\nu_0\right)}} \left(\frac{Y_1}{\eta_{SP}}\right)^{\nu_0 \gamma_\phi' \gamma_\psi'} \left(\frac{Y}{\eta_{SP}}\right)^{\frac{\left(1-\nu_0\right)\alpha}{(\alpha+\beta)\left(1+\beta_{E_J}\right)}} \\
& \cdot \left(\frac{M_0}{m_0}\frac{C_M}{l_{IU}}\right)^{0,5\nu_0\gamma_\psi'} q_d^{\nu_1'}
\end{aligned}
\tag{28}
$$

thus:

$$
\begin{aligned}
K_{E_Q} = & \frac{1+\frac{\beta_\psi'}{\lambda}}{\left(\frac{\beta_\psi'}{\lambda}\right)^{\frac{\beta_\psi'}{\beta_\psi'+\lambda}}} \left(K_{E_l}^Q L_Q\right)^{1-\nu_0'} \left[K_\psi' \left(200K_\phi'\right)^{\gamma_\psi'} k_{hr}^{\gamma_\phi' \gamma_\psi'}\right]^{\nu_0'} \\
& \cdot \left(a_{SP}^1 I_{SP_0} c_k\right)^{\frac{\beta_{E_J}\left(1-\nu_0'\right)}{1+\beta_{E_J}}} \left(a_{IU}^1\right)^{\nu_2'} I_{IU_0}^{\nu_0'\left(1-\gamma_\psi'\right)} i_{IU}^{\nu_3'} \cdot \left(a_{SP}^1 K_I K_N\right)^{\nu_0 \gamma_\phi' \gamma_\psi'}
\end{aligned}
\tag{29}
$$

The objective functions of the model of optimization of pumping station with movable installations

In the case of the irrigation through aspersion based on equipments with the distributed debit on the installation's length, the objective function of the model of optimization of pumping station with movable installations is:

$$
E_A^1 = A\frac{d_0}{K_P} + f_J^{0,88234} f_l \frac{B}{K_P^{0,03686}} d_0^{0,18594} + C\frac{\sqrt{K_P}}{d_0^{2,522}} + + f_L D \frac{d_0^{1,21687}}{K_P^{0,23734}} + AH_g, \tag{30}
$$

with:

$$
\begin{cases}
A = 1,22426\frac{Y_1}{\eta_{SP}} q_d \\
B = 382,42\frac{n^{0,14864} k_{IU}^{0,07373}}{k_s^{0,11766}} \left(\frac{Y_1}{\eta_{SP}}\right)^{0,19935} q_d^{0,51885} \\
C = 937,88\frac{i_{IU}}{k_{IU}} q_d \\
D = 1,61788\left(\frac{M_0}{m_0}\frac{C_M}{l_{IU}}\right)^{0,61509} \left(\frac{Y_1}{\eta_{SP}}\right)^{0,28653} \cdot q_d^{0,38491} k_{IU}^{0,61509}
\end{cases}
\tag{31}
$$

In the case of utilization of the equipments with concentrate debit, the objective function of the model of optimization of pumping station with movable installations is:

$$
E_S^1 = \frac{A_1}{L} + B_1\frac{L}{Q} + \frac{C_1}{Q} + D_1 L Q^{1,84} + + f_s^{0,8834} f_l E_1 \frac{Q^{0,07373}}{L^{0,07997}} + F_1, \tag{32}
$$

with:

$$\begin{cases} A_1 = 10^4 \frac{M_0}{m_0} \frac{C_M}{l_{IU}} \\ B_1 = 0,175 i_{IU} q_d \\ C_1 = 0,175 I_{IU_0} q_d \\ D_1 = 1,22426 \frac{Y_1}{\eta_{SP}} q_d \\ E_1 = 746,06 \frac{n^{0,14864} k_{IU}^{0,07373}}{k_s^{0,11766}} \left(\frac{Y_1}{\eta_{SP}}\right)^{0,19935} \cdot q_d^{0,51885} \\ F_1 = D_1 \left(H_g + H_0\right) \end{cases} \tag{33}$$

The functions involved in the mathematical model of the optimum size

Pumping station with aspersion

The optimum diameter equivalent of the sprin kler's nozzles d_o is calculated with the following formula:

$$d_0^* = \frac{3,19.i_{IU}^{0,341}}{f_s^{0,212}.f_l^{0,240}.f_L^{0,341}} \cdot \frac{k_s^{0,028}}{n^{0,036}} \cdot \frac{K_P^{0,245}}{k_{IU}^{0,386}} \cdot \frac{q_d^{0,143}}{\left(\frac{Y_1}{\eta_{SP}}\right)^{0,068} \left(\frac{Y}{\eta_{SP}}\right)^{0,048} \left(\frac{M_0}{m_0} \frac{C_M}{l_{IU}}\right)^{0,028}} \tag{34}$$

The optimum length of the installations with debit uniform distributed is L^* calculated with the following formula:

$$L^* = 12721,22 \frac{K_P^{0,30623}}{k_{IU}^{0,03939}} \cdot \frac{\left(\frac{M_0}{m_0} \frac{C_M}{l_{IU}}\right)^{0,24714}}{\left(\frac{Y_1}{\eta_{SP}}\right)^{0,28653} q_d^{0,24714} d_0^{1,54786}}. \tag{35}$$

The debit of the installation of watting Q^* is calculated with the following formula:

$$Q^* = 2,438 \cdot 10^{-4}. \frac{d_0^{*2,522}}{\sqrt{K_P}}.L_*^{0,95264} \tag{36}$$

The medium total specific consumption yearly of energy is calculated with the following formula:

$$\begin{aligned} E_1 = & 1,2243. \frac{Y_1}{\eta_{SP}}.q_d.H_g + 1,2243. \frac{Y_1}{\eta_{SP}}.q_d \\ & \cdot \frac{d_0}{K_P} + f_L.117,13. \left(\frac{Y_1}{\eta_{SP}}\right)^{0,287} \cdot \left(\frac{M_0}{m_0}.\frac{C_M}{l_{IU}}\right)^{0,615} \\ & \cdot q_d^{0,385}.k_{IU}^{0,615}. \frac{d_0^{1,217}}{K_P^{0,237}} + f_J^{0,882}.f_l 382,35. \frac{n^{0,149}}{k_s^{0,118}} \\ & \cdot \left(\frac{Y_1}{\eta_{SP}}\right)^{0,199}.q_d^{0,519}.k_{IU}^{0,0737}. \frac{d_0^{1,217}}{K_P^{0,037}}. \end{aligned} \tag{37}$$

Pumping station with equipments with concentrate debit

The debit Q_0^* and the length L^* optimum of the installation of wetting is calculated with the following formula (the length is normalized in accordance to standardize):

$$Q_0^* = 59,3.\frac{f_L^{2,26}}{f_J^{2,05} f_l^{2,32}}.\frac{k_s^{0,273}}{n^{0,345}}.\frac{\left(\frac{Y_1}{\eta_{SP}}\right)^{0,147}}{\left(\frac{Y}{\eta_{SP}}\right)^{0,463}} \cdot \frac{\left(\frac{M_0}{m_0}\frac{C_M}{l_{IU}}\right)^{1,13}}{q_d^{0,013}}; \tag{38}$$

$$\begin{aligned} L^* &= 22,59\frac{\sqrt{\frac{M_0}{m_0}\frac{C_M}{l_{IU}}}}{\sqrt{q_d}}\sqrt{\frac{Q_0}{1+2,64\cdot 10^{-6}\frac{Y_1}{\eta_{SP}}Q_0^{3,49}}} \\ &\cong 39,21\frac{\sqrt{\frac{M_0}{m_0}\frac{C_M}{l_{IU}}}}{\left(\frac{Y_1}{\eta_{SP}}\right)^{0,065}\sqrt{q_d}}Q_0^{0,34}. \end{aligned} \tag{39}$$

The medium total specific consumption yearly of energy is calculated with the following formula:

$$\begin{aligned} E^1 =& 1,224\frac{Y_1}{\eta_{SP}}q_d\left(H_g+H_0\right)+f_J^{0,731}f_l^{0,829}f_L^{0,167} \\ &\cdot f_Q 773,39\frac{n^{0,123}}{k_s^{0,098}}\cdot\left(\frac{Y_1}{\eta_{SP}}\right)^{0,011}\left(\frac{Y}{\eta_{SP}}\right)^{0,165} \\ &\cdot\left(\frac{M_0}{m_0}\frac{C_M}{l_{IU}}\right)^{0,083}q_d^{0,519}. \end{aligned} \tag{40}$$

Conclusions

The efficient working of irrigation systems establishes a strong growth economic through the increase of the productivity at hectare of the irrigated crops.

The processes of optimization follow the optimization of the specific consumption of water and the determination of the specific debits of dimensioning of the system's elements.

The model of optimum admeasurements of the irrigation size through pipes under pressure it applies at any conditions of water demand and take into account by the possibilities of equipment offered by present technique:

1. For irrigation through aspersion:
    - The diameter of the aspersion's nozzles $d = 5 \div 8$ mm;
    - The distance between the aspersions $l_{as} = 18$ m;
    - The diameter of the aspersion wing $D_{ar} = 100$ mm.
2. For the irrigation through EUBA installations:

- The diameter of pipes D_{ar} = 150 mm;
- The installation's debit $Q_i = 20 \div 30$ l/s;
- The charge necessary at hydrant $H_H = 7 \div 10$ m.

3. The fix network is achieve by the azbo-cement tubes or by PVC with $\phi = 400 \div 1000$ mm (the principal pipes).

The results of researches serve at the optimum designing of point of view energetic of the fittings out for irrigations in the zones with plan relief and in steep, the methods proposed allow a reduction with $20 \div 25$ % of the consumption of energy generated by the irrigation through aspersion.

References

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