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CONTRIBUTIONS AS FOR THE OPTIMIZATION OF THE PUMPING STATIONS UNDER PRESSURE

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Lucrarea urmareste ca în baza analizei legăturilor dintre parametrii constructivi şi funcționali, consumurile anuale de energie şi cantitatea de energie înglobată în amenajare să formuleze o metodologie de stabilire a parametrilor optimi de dimensionare a statiilor de pompare pentru punerea sub presiune, a rețelelor de irigații, a ploturilor de irigații prin aspersiune care asigură un consum optim de energie pe durata de serviciu a amenaăarii (energia operațională şi energia înglobată în rețea, echipament şi construcții), precum şi a condițiilor în care acestea pot fi obținute.

The paper follows the analyze of the connections between the constructive, working parameters, the annual energy consumptions and the energy quantity included in fitting out; it is formulated 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.

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

1. Introduction

The optimum irrigation plots through pipes under pressure can be defined theoretic for any area and in any climatically conditions. The technique of irrigation limits this theoretical possibility. The technical principal restriction is the maximum diameter's value that can be used on antennas, respective principled pipes. These considerations reduce the area that can be covered by a optimum plot S_{max} = f(q, q_d , T_o). The all specific consumption of energy generated by the

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network, while optimum at the plot level, have values breeder with *S* and *n.* It is prefer the variants of optimum plot with *S* and *n* lesser.

It is necessary an optimization of ensemble at the level of the big irrigation systems, arises from the analysis of more variants organised through the combination of the infrastructures with network's densities different, with the optimum plots. The optimum solution of ensemble corresponds with the variant that have the total specific consumption of energy minimum on ensemble.

The optimization of the technique of wetting visa the choice of the best technology of administration of the wettings what, respecting the restrictions imposed by the necessity of the medium's protection, ensure a social level of work acceptable for the personnel of execution in the conditions of the minimization of the specific consumption total average annual of energy CSTMAE associated to the achievement of the respective function of water's distribution at plot's level.

2. Nomenclature

Latin symbols

a Relative spore of debit pumped in gap hours
a_{PSP} Average overall quota in pumping station
a_{NP} Average overall quota in pipe
C Annual average specific consumption of energy generated by the water's transport in plot's network
d Pipe's rated diameter
E_R Unitary energy involved in the fixed network
E_{WI} Unitary energy involved in pipes
g Gravitational acceleration
H Load
H_g Static pressure load
H_t Head loss in discharge pipes
I_{WIo} Investment in pipes installations
J_o Hydraulic slope
J_o^* Optimum average piezometer slope
k Knot's number
K_j Hydraulic slope parameter
k_S number of served networks by the pumping station under pressure
L_{CP} Principled pipe's length
L_{CS} Secondary pipe's length
L_H section's length of admeasurements
l_{WI} wetting installations' length
M_c Deficit of calculation with a frequency commensurate to the fitting out's

category of importance

m_o Average doze

n Number of secondary pipe

n_m number of moves

n_u number humectation

Q Flow rate

q_d Specific debit of admeasurements

S Area served

t_h Time (hours/day)

t_z Time (days),

W Water volume

Y Specific features of the water consumption for irrigation

Greek symbols

η_p average output of the water's pumping

η_u Gross output of the water's usage

α Load coefficient

β Constant of hydraulic slope

γ Constant of hydraulic slope

3. Problem definition

It is calculate the following parameters for the determination of the structure and of the functional, energetic and economic specific features of the optimum plot:

1. for the determination of the geometry in plane of the optimum plot:

- the length wetted of secondary pipe (antenna) L_{cs}; the length wetted of principled pipes L_{cp} (number of secondary pipe):

$$L_{CP} = n.L \,. \tag{1}$$

- The really length of the principled pipes L_{cpef}; the factor of shape of the sector wetted of antenna l:

$$l = \frac{L}{L_{CS}} .. \tag{2}$$

- The factor of shape of the plot f; the unitary length of the secondary pipes L_{cs1}; the unitary length of the principled pipes L_{cp1}; the section's length of admeasurements L_H:

$$L_H = L_{CPef} + L_{CS} = \frac{(n-1).l+1}{l} \,. \tag{3}$$

2. For the determination of the functional and power specific features of the plot with the optimum geometry by the s area it is established the following parameters:

a. the debit of admeasurements of the ensemble pumping station under pressure – network is a multiple of the modulus debit Q_i and depend on the size of the area served S and the specific debit of admeasurements q_d , the debit of section j of the antenna j = 1, 2, …, n_t , the debit of the k section of principled pipes, k = 1, 2, …, n/2, (k_S – number of served networks by the pumping station under pressure, k_S = {1, 2}, figure 1):

$$S_o = \frac{L^2}{5000.l};\; S = \frac{k_S.n.L^2}{5000.l}. \tag{4}$$

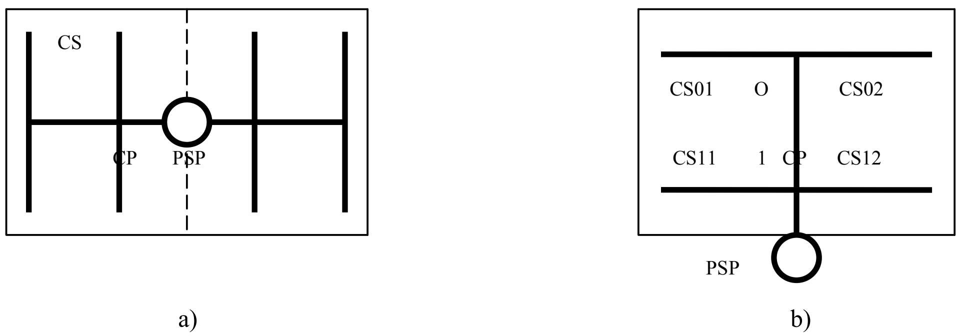

Fig.1. The scheme of the irrigation system under pressure with networks:
a) k =1; b) k =2.

In the irrigation season, the ensemble PSP – network – installations of wetting distributes a water volume W covering a water deficit $M \le M_c$ on the section of area S and the water wastage with output of water's usage η_u :

$$W = \frac{10.M.S}{\eta_u}. \tag{5}$$

M_c (mm) represents the deficit of calculation with a frequency commensurate to the fitting out's category of importance; it value can be established through to take into account the relations water – production and water – energy, determined in the conditions of the system. This service is ensured through the management, on each position of waiting of wetting installations, of a number humectation n_u with an average doze m_o (mm):

$$m_o \le 10.\gamma_v.H_a.\left(W_c - W_m\right);\; M = n_u.m_o. \tag{6}$$

Depending on the distance between the positions of waiting of the wetting installations l_{WI} it is wet at a waiting a section of area s_{io} and it has to effectuate a number n_m of moves:

$$s_{io} = L.l_{WI};\; n_m = \frac{n_u.10^4.S}{L.l_{WI}}. \tag{7}$$

It is calculate the specific debit of admeasurements of the ISP's elements q_d (l/s.ha) adequate to the deficit of calculus from top month of the irrigation season m_v that has to cover through the operating of the irrigation system under pressure ISP in t_z (days), time by t_h (hours/day) with an gross output of the water's usage η_u:

$$q_d = \frac{2,78.m_v}{\eta_u.t_z.t_h}. \tag{8}$$

b. Optimum average piezometer slope PPMO J_o^* proper of the debit's transport of admeasurements section by optimum diameter.

c. Average piezometer slope PPM J_o of admeasurements of the antennas from the nodes $k \neq 0$.

d. The load necessary at pumping station PS for the water's transport in network will be established by the section's length of admeasurements L_H and J_o^*.

e. The power fitted in the pumping station for the water's transport in the network it is established of the debit of admeasurements of plot and by the load necessary for the water's transport in network. Also it is important the reservation of power necessary in the working of the aggregates of pumping k_M and the average output of the water's pumping η_p.

f. The average power absorbed by the PS for the water's transport in the network on the period of existence of the irrigation system.

3. For the determination specific consumption of energy generated by the water's transport through network of the irrigation plots it calculate the following parameters:

- the unitary energy involved in the fixed network:

$$E_R = \frac{5000}{n.L}.\left\{\left[l.(n-1)+n-2\right].i_o + \left[(n-1)l.\phi(n)+n.\psi(n)\right]\right\}.\frac{K_J^{\alpha/\beta}.(n_t.Q_{IU})}{J_o^{\alpha/\beta}};$$

$$\phi(n) = \frac{2.\sum_{i=0}^{\frac{n}{2}-1}(2.i)^{\alpha.\gamma/\beta} + n^{\alpha.\gamma/\beta}}{n-1}; \quad \psi(n) = \frac{2.\sum_{i=0}^{\frac{n}{2}-1}(1+2.i.l)^{\alpha/\beta}.\sum_{j=1}^{n_t}\left(\frac{j}{n_t}\right)^{\alpha.\gamma/\beta}}{n.n_t}. \tag{9}$$

- The unitary energy involved in the PS for the water's transport in network:

$$E_{PSP} = \frac{5000.l.I_{PSo}}{k_S.n.L^2} + \frac{K_I.K_N}{\eta_p}.q_d.\left(H_g + H_H + H_t\right). \tag{10}$$

- It is established the unitary energy involved in pipes (wetting installations):

$$E_{WI} = \frac{q_d}{Q_{WI}}.\left(I_{WIo} + i_{WI}.L\right). \quad (11)$$

- Annual average specific consumption of energy generated by the water's transport in plot's network:

$$C = \frac{K_N.q_d.T_o}{k.\eta_p}.\left[\left(\frac{\overline{q}}{q_d}\right)^2 + \frac{\overline{q}}{q_d}\right]. \quad (12)$$

- Annual average specific consumption of energy generated by the service and the exploitation of the transport system under pressure of the water, (k_{re} – coefficient wages):

$$C_I = C_{IPS} + C_{NP} + C_{IWI} + k_{re}.C_p;\ \mathrm{C_{Ij}} = a_j.E_j;\ j \in \{PS,\ NP,\ WI\}. \quad (13)$$

- It is established the annual average specific consumption of energy for the WI's move:

$$C_m = \frac{M_o.r_m.10^4}{m_o.l_{WI}.L}. \quad (14)$$

- CSTMAE generated by the water's transport in the irrigation plot with the pipes under pressure, [4]:

$$C = \frac{5000}{n.L}.\left\{\frac{a_{PSP}.E_{PSPo}}{k_s.L} + a_{NP}.i_o.[(n-1).l + n - 2]\right\} + a_{WI}.\frac{q_d}{Q_{WI}}.$$
$$.(E_{WIo} + i_{WI}.L) + \frac{M_o.r_m.10^4}{m_o.l_{WI}.L} + \frac{Y_1.q_d.K_N.K_1.a_{PSP}}{\eta_p}.$$
$$.\left(H_g + H_o + h_{rWI} + \frac{[(n-1).l + 1].L.J_o}{l}\right) + \quad (15)$$
$$+ \frac{5000.a.a_{NP}.[(n-1).l.\varphi(n) + n.\psi(n)].K_J.(n_t.Q_{WI})^{\frac{\alpha.\gamma}{\beta}}}{n.L.J_o^{\frac{\alpha}{\beta}}}.$$

The optimisation problem OP matters in the minimization of the CSTMAE demanded by irrigation through pipes under pressure of the relation climate ground – plant. It must be respected the restrictions of functional order and it were adopted the standardized dimensions.

It must be found size's values J_o , *l, L* what, depending on the equipment's category of wetting used (Q_{WI} , H_o , d_o , K_p) lead at the minimum of CSTMAE, equation (15):

$$\min C=\min C\left(J_o,\ l,\ L,\ Q_{WI},\ H_o\right);\mathrm{Q_{WI}}=\frac{K_{WI}.K_Q.d_o^{\beta_Q}.L^{\gamma_Q}}{K_p^{\frac{1}{2}}};\tag{16}$$

$$H_o=\frac{d_o}{K_p};\mathrm{h}_{\mathrm{rWI}}=\frac{k_{hr}.d_o^{\beta_H}.L^{\gamma_H}}{K_p}.$$

From the condition of the minimum CSTMAE generated by the wetting's realization is established the structure of the wetting installations used and the charge necessary at hydrant.

The piezometer slope is expressed depending on depending on the length l and the specific debit of admeasurements, [4]:

$$J_o=\left[\frac{l.(n-1).\varphi(n)+n.\psi(n)}{n.\left[(n-1).l+1\right]}\right]^{\frac{\beta}{\alpha+\beta}}\cdot\frac{K_J^{\frac{\alpha}{\alpha+\beta}}}{\left(K_N\cdot\frac{K_I}{a}\cdot\frac{a_{PSP}}{a_{NP}}\cdot\frac{\beta}{\alpha}\right)^{\frac{\beta}{\alpha+\beta}}}\cdot$$

$$\cdot\frac{1}{\left(\frac{Y}{\eta_p}\right)^{\frac{\beta}{\alpha+\beta}}}\cdot\left(\frac{5000.l}{L^2.q_d}\right)^{\frac{\beta-\alpha\gamma}{\alpha+\beta}}.\tag{17}$$

The reduction of PPM J_o has like effect a decrease of the operational consumption of energy for pumping and an enlargement of the energy included in the network. The admeasurements of the SPP – network ensemble is effected for an optimum average piezometer slope PPMO, J^*_o , established from the minimum's condition of the CSTMAE established of water's transport in the plot's network analysed.

4. The experimental results

The constants for the calculation of the CSTMAE are the following values: a_{PSP} = 0,105; a_{NP} =0,075; a_{WI} = 0,175; k_{re} = 0,06; k_m = 1,05; k_S = 1; n = 4; η_{PS} = 0,65 %; a = 1140; α = 1,53; K_I = 1100; K_N = 0,0103; i_o = 70; if Q is express in l/s $K_J = 1,89.10^{-9}$; if Q is express in m^3/s $K_J = 1,56.10^{-3}$; β = 5,08; γ = 1,97, m_o = 60 mm; t_z = 30 days; t_h = 20 hours, (figure 2 for H = 40 m and figure 3 for H = 75 m).

Depending on the tipe of irrigation it is used the following values:

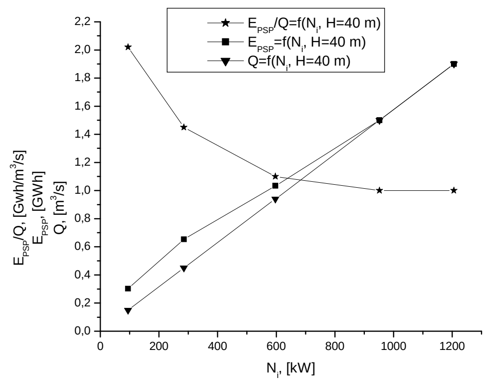

Fig.2. The energy involved in PSP depending on the power fitted for load H = 40 m.

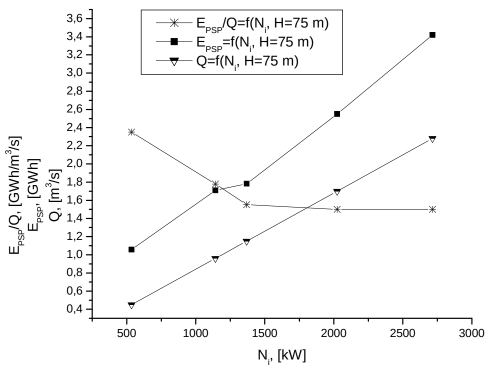

Fig.3. The energy involved in PSP depending on the power fitted for load H = 75 m.

- In the case of aspersion installations: l_{WI} = 18 m; k_i = 2; H_g = 4 m; r_m = 23 for moves mechanized of wetting installations and r_m =52 for hand moves; i_{WI} = 68,4 for moves mechanized of wetting installations and i_{WI} = 73,1 for hand moves; E_{WIo} = 4200.

- In the case of EUBA installations: l_{WI} = 144 m; k_i = 1; H_g = 7 m; r_m = 275; i_{WI} = 106; E_{WIo} = 1712.

The wetting installations are the constants:

- In the case of aspersion installations: $k_Q = 2{,}43.10^{-4}$; β_Q = 2,52; γ_Q = 0,95; $k_{hr} = 5{,}06.10^{-11}$; β_H = 5,07; γ_H = 2,49.

- In the case of EUBA installations: $k_{hr} = 4{,}22.10^{-5}$; β_H = 1,84.

Proper to the mathematical model it is worked out the logical scheme of an automat calculus programme, which will be used at the elaboration of many calculus programmes.

The optimization model it is 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 optimum values established through the method of optimization for the irrigation through aspersion and through EUBA installations in different conditions are presented in table 1.

5. Conclusions

It is strong interactions between the hydro technical systems, surrounding environment and the social – economic conditions; it exist relative indicators in the structure of the consumption energy that defer to the mode how the surrounding environment it is affected by the hidrotechnics fitting out. The operational consumption of energy for working grows up from minimum values in the case of the gravitation solutions, unto maximum values adequate to the installation with pumping.

The operational consumption of energy for service and guidance of the fittings up's exploitation represents annual a fraction from the energy involved but, on the standardised duration of existence of the workings it has same order of the size with it.

CSTMAE has relative values elevated in the case of the systems of gravitation irrigation (because of the involved energy's peculiarities that prevail in the structure and present a minimum, proper to the mixed solution with a special index of pumping). For to ensure the fitting out's profitableness, the system ought to present a period of existence least equal with the necessary to the recovery of the resources anticipated consumed.

The intensive application of the irrigation matters economic through the following indicators: the time of system's reply, the stability on operating and reability.

Table 1.

Optimum parameters for the optimum plot in different conditions

Parameters assessed:			Values			
M_o (mm)			120	180	240	300
m_v (mm)			60	80	100	120
η_u (%) Aspersion installations			80	85	90	95
η_u (%)EUBA installations			70			
Optimum parameters:			Values			
Type irrigation	Aspersion installations	T_o (hours)	2000	2077	2057	2000
		q_d (l/s.ha)	0,347	0,436	0,514	0,585
		d_o (mm)	6,5			
		K_p (mm/m)	0,352	0,362	0,388	0,380
		L_{CS} (m)	2016	1584	1296	1152

		L_{CP} (m)	1368			
		L_{CPef} (m)	1026			
		S (ha)	551,6	433,4	354,6	315,2
		J_o	0,01	0,00837		0,0065
		Q_{PSP} (l/s)	192	189	182	184
		H_{PSP} (m)	56,4	47,2	41	38,7
		H_H (m)	26,3	25,7	24,3	24,7
		H_t (m)	30,1	21,5	16,7	14
		C (kWh/ha)	695,6	763,8	818,8	877,6
	EUBA installations	T_o (hours)	2000	2077	2057	2060
		q_d (l/s.ha)	0,397	0,494	0,579	0,654
		L_{CS} (m)	1584	1224	936	792
		L_{CPef} (m)	1080	1134	1188	1188
		S (ha)	456,2	370,1	296,5	250,9
		J_o	0,0098	0,0080	0,0070	0,0063
		Q_{PSP} (l/s)	181	183	172	164
		H_{PSP} (m)	37,6	30,8	26,4	23,6
		H_H (m)	11,7	12,1	11,7	11,3
		H_t (m)	25,9	18,7	14,7	12,3
		C (kWh/ha)	704,8	776,4	833,4	897,7

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

The hydro technical fittings out for irrigation ought to present o great adaptability at technological changes that facilitate the productivity's maintenance and of the unitary consumptions in the contiguously to the values ensured by the best technologies. 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 ÷ 25 % of the consumption of energy generated by the irrigation through aspersion.

R E F E R E N C E S

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