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# Regional Issues in Water Supply, Sewage Pumping and Drainage

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**Abstract: As a joint interest, the metering of water consumption ensures low specific consumption of 80-150 l/capita day, values considered to be normal. Where the metering was delayed, the specific consumption increased even up to 500 l/capita day, thereby increasing pipeline flow Q and water velocity v, hydraulic loss $h_r$, pumping heads H, powers P and energy E consumed by pumps. In areas of Eastern Europe where the water consumption metering was introduced, the specific consumptions of water decreased to normal levels and the values for Q, v, $h_r$, H (e.g., from 58 m to 25 m), P and E accordingly decreased. H decreasing raised a new problem, namely the failure of the pumps adopted to operate at high H values, by operating at low H values. Other problems occurred at the draining pumping stations which were flooded and put out of operation even when pumping was strictly necessary. All these issues resulted in the original technical solutions, succinctly described in the paper.**

**Keywords**: drainage, inventions, optimal solutions, pumping, sewerage, water supply, water specific consumption, water metering.

## 1. SPECIFIC WATER CONSUMPTION

Introduced a long time ago in the developed countries, the individual metering of water consumption, including household subscribers, has always maintained a low specific consumption of 80-150 l/capita day. In other parts of the world, including Romania until 1990, although the centralized water supply extension, the water consumption has not been rationalized due to the lack of metering the household customers. Consequently, the specific water consumption increased to 300 - 400 l/capita day in cities from Romania and even up to 500 l/capita day in St. Petersburg (formerly Leningrad), Russia [1]. To understand the consequences of this situation and to optimize the remedial solutions, the application of some quantitative relations is required. These relations, established in the literature [2-5] are listed below.

## 2. THE CALCULUS OF RELATIONS

The average Speed of the liquid through a pipeline will be directly proportional to the flow Q and inversely proportional to the cross-section area A:

$$v = \frac{c_1 \cdot Q}{A} \qquad (1)$$

where $c_1$ is a constant (according to the measuring units).

The hydraulic loss $h_r$ is directly proportional to the square speed v or to the square flow Q (long pipelines are considered, so only the linear hydraulic loss are took into account):

$$h_r = c_2 \cdot v^2 \qquad (2)$$

where $c_2$ is a constant (according to the measuring units).

$$h_r = c'_2 \cdot Q^2 \qquad (2')$$

where $c'_2$ is a constant (according to the measuring units).

The required pumping head H for a water supply basic pumping stations consists of pumping head Ho at which water rising is necessary and the amount of hydraulic losses $\Sigma h_r$ in the pump to user track;

$$H = H_0 + \sum h_r \qquad (3)$$

The absorbed power by pumps, according to the density of the pumped liquid ρ, to the gravity g, to the pumping head H, to the flow Q and to the efficiency η, is obtained by the relation:

$$P = \frac{\rho \cdot g \cdot H \cdot Q}{\eta} \qquad (4)$$

The energy E is proportional with the absorbed power P and with the operating time t:

$$E = P \cdot t \qquad (5)$$

Taking into account that power P varies in time, the exact relation for energy is the following:

$$E = \int P \cdot dt \qquad (5')$$

In a centrifugal pump, by passing from a speed $n_0$ to a speed $n_1$, the values are modified for the flow

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from $Q_0$ to $Q_1$, for the pumping head from $H_0$ to $H_1$ and for the efficiencies from $\eta_0$ to $\eta_1$, according to the relations:

$$Q_1 = Q_0 \cdot \frac{n_1}{n_0} \quad (6)$$

$$H_1 = H_0 \cdot \left(\frac{n_1}{n_0}\right)^2 \quad (7)$$

$$\eta_1 = (1-\eta_0) \cdot \left(\frac{n_0}{n_1}\right)^{0.1} \quad (8)$$

Since the relation (8) gives a small change of the efficiencies by the reduction of the speed limit to maximum 30%, a simplified formula can be admit [3]:

$$\eta_1 \approx \eta_0 \quad (8')$$

## 3. THE WATER CONSUMPTION METERING EFFECTS

Where the specific consumption of water increased due to lack of metering at consumers, the flow rates Q, the pipelines water speed v, hydraulic loss $h_r$ and required pumping head H to pumping stations increased, and pumps consumed high powers P and energies E, consequently, according to the relations (1) to (5 ').

In Romania, the generalization of individual household water metering started in fact in 1995, due to the very high level of specific consumptions. Where the metering was introduced, it offered an incentive to the users to save water, and in several years the specific consumption decreased to normal. This situation raised a new problem, once with consumption, the flows Q, water speed v in pipelines and, hydraulic loss $h_r$ and pumps required pumping heads H especially, decreased.

For example, in Bucharest, between 1995 and 1998, a new drinking water pumping station Grozavesti was made, equipped with 9 vertical electro pumps with double flow of 600kW each (imported from Germany), among which 2 electro pumps are provided with adjustable speed by conversion of the power supply frequency of the driving motors. However, while achieving new pumping stations the widespread metering of water individual consumption began, including household subscribers. As a result of metering, the values of flows Q, the water speed v in pipelines – according to the relation (1), the hydraulic losses $h_r$ – according to the relations (2) or (2') and the pumping highs H required by the pumps – according to the relation (3) have significantly decreased. Thus, the new performant pumps (i.e., high efficiencies at high pumping heads H at the time when have been contracted), arrived inappropriate by pumping with low efficiencies at low pumping heads H. Exceptions are the two pumps with variable speed which, by lowering the speed, arrived to obtain maximum pump efficiency for a lower pumping head H, according to relations (6) to (8').

In Timisoara, at the 2-4 Drinking Water Plant of the city, a new pumping station equipped with two horizontal electro pumps with double flow was achieved, contracted after an auction organized in 1996, when the specific consumption was still high and pumping heads H required by the pumps were high, the H value of 58 m was requested in auction. However, in parallel with the achievement of this new pumping station, the passing to widespread metering of individual consumption of water was achieved, and as a result, the values for Q, v, $h_r$ and H have decreased, e.g., H reached the values even below 25 m.

These two examples are typical, showing a general problem, i.e., H values gradually over decrease after metering, and so adopted pumps for other H values, arrived to be inappropriate and, without new investment, they can pump only with the discharge valves partially closed, with a low overall efficiency, so wasting much of the energy saved by reducing water consumption.

The issue is important, occurring in every place where the specific consumption was very high before metering, so in the mostly Romanian cities and beyond.

In many cases so far, the problem received solutions under the current technical possibilities, more expensive and/or with reduced functionalities, but also gave the opportunity for the development of a new solution, based on the original technical solutions [6-7].

Moreover, throughout the world, in a place where the water consumption in the present or in the future will significantly increase (by the fast growth of population, e.g., by the influx of rural population in emerging countries, or by the appearance and/or development of major water consumer economic agents), appears the reverse problem, i.e., significant increase of Q, v, $h_r$, H, P and E values.

The new solving by original solutions is suitable for the both water consumption decreasing or increasing, for the pumping in water supply, sewage, drainage sector and also in other areas.

The problem occurs in draining. Thus, many pumping stations draining-existing PSD was found that the maximum flow differs substantially real need (in most cases is greater) considered the design flow. And drainage is a very important role in many areas of the world. Thus, in Romania, 3.1 million ha, of those four million hectares required, are furnished by defence - damming and draining to eliminate, or at least minimize the damage caused by flooding and excess moisture in low agricultural areas.

In addition, at many pumping stations have found two specific issues outlined below in Chapter 4 and 5.

## 4. IN SOME CASES, EFFICIENCY ARE LOW

To obtain the required values of flow pumped Q and the pumping height H, so the water supply, sewerage, drainage and other areas, in many cases of PS with centrifugal pumps should be adopted value of the rotor diameter D pump different from the optimal value (which pumps have maximum efficiency) and PS pumps with low efficiency and require large installed power. For example, the question is equipping a pumping station - PS draining pump flow to be $Q_{PS}$ = 22 400 m3 / h pumping at a height H = 7m.

Solution 0 (classical solution) consist in PS equipped with pumps Brateş600 with speed $n_0$ = 580 rpm. Diameter $D_0$ of these pumps are adopted by the characteristic curves of type (according to drawing AVERSA no. M1311 D132). Ultimately resulting $D_0$ = 620 mm. [11] is considered the curve Q-H and the efficiency curve corresponding to $D_0$ = 620 mm. From these curves results that at H = 7m pump has a flow $Q_{P0}$ = 3200m3 / h and an efficiency $\eta_{P0}$ = 70.7%.

Shaft of the pump power $P_{shaft0}$ results:

$P_{shaft0}$ = 9, 81 x $Q_{P0}$ x H / $\eta_{P0}$ = 9,81 x (3200 $m^3/h$ : 3600 s/h) x 7m / 0,707 = 86.337kW

Coating, rated drive motor $P_{mot0}$ is adopted:

$P_{mot0}$ = 100kW

PS wide is obtained, with seven groups of pumping also:

- flow station $Q_{PS0}$ = 7 x $Q_{P0}$ = 7 x 3200$m^3/h$ = 22400 $m^3/h$;

- installed power station $P_{PS0}$ = 7 x $P_{mot0}$ = 7 x 100 kW = 700 kW;

- pump efficiency $\eta_{P0}$ = 70,7%.

Obviously, is a modest efficiency, imposed by the classical solution limits at the pump, directly driven by the engine, can only have the same engine speed.

So, in many cases appears the disadvantage that at the commissioning, PS with classic aggregate have low efficiency and require large installed power.

## 5. THE DRAINAGE EXIST MORE PS WHICH WERE FLOODED AND SHUT DOWN

Aggregates several pumping stations (PS) of draining can only pump in dry PS, and if PS is flooding, aggregate stop [8,9] exactly when pumping is necessary, case often appear in 2005 (only Timis county at18 PS).

PS supplementation equipping these units with classical submersible [5,9,10] PS reliable partly PS because, to a new flood of PS, non rehabilitated aggregates of current facilities would be decommissioned, leaving only to aggregates submersible pump, which would ensure a flow lower than necessary.

However, supplemented PS had the overall efficiency lower because:

- classical submersible aggregates generally have higher overall efficiency;

- non rehabilitated aggregates of current equipment being used, have low efficiency.

In addition, fitting supplement with submersible aggregates is very expensive (involving high costs for PS construction change for adding tens of meters of pipe, for charge to connecting to the electrical network of submersible aggregates and for the acquisition of submersible aggregates, and sometimes for replacing electrical transformers with others, with greater powers).

So, a disadvantage is the unreliability of existing aggregates of many PS draining, aggregates that can only pump in dry PS, while these PS were and can be flooding, and removing disadvantage, even only partially, by fitting supplement with conventional submersible units, is expensive and does not provide large overall efficiency of PS.

## 6. SOLUTIONS FOR THE TWO NEW SPECIFIC PROBLEM

Further, the known possible solutions, i.e., 6.1 to 6.7 and the new solutions, i.e., 6.8 are presented.

6.1 At low decreased of H values, the pumps impeller diameters are getting smaller. So the necessity of the partial closure of the valves is eliminated, but there appear other disadvantages, i.e., the pump efficiency is slowly decreasing; the pumps must be dismounted and mounted, remaking the alignment of the shafts; if after diameters decreasing, the H values increase, there can be no return to the original situation, and pump new impellers are required.

The solution is limited to small and irreversible H decreases.

6.2 The pumps are (repeated) retrofitted by redesigning the hydraulic part and replacement of some components to better meet the new conditions Q, H, other than those provided by the initial design. In this case also, some disadvantages appear, i.e., the pumps must be dismounted and mounted, remaking the alignment of the shafts; if H values further decrease, the discharge valves have to be partially closed, or a new retrofitting is made.

6.3 The driving motors are replaced by others that operate at lower speed and powers according to the new decreased H values. Being of very advantage, in all the cases it must be calculated if this solution is possible.

6.4 The pumps speed is decreased by using gearbox and by the (repeatable and reversible) replacement of the planet wheels. The wheels replacing require dismount and mount of the gearbox, and the alignment of the shafts. There are few cases of pumps with reduction gears but in all this cases this very advantageous solution must be considered. In such cases it may be also lucrative the replacing of the driving motor of the pumps by others with lower powers (in order to leave an optimum motor loading, operating at high efficiency and high cosφ).

6.5 On pumps being directly driven by motors, between the pumps and motors there are mounted mechanic Speed reducers (having very high efficiencies, about 99 %). By means of the reducers, the pump Speed is (repeatable) decreased to the required level corresponding to the decreased H values. In some of these cases it may be also lucrative to replace the pumps driving motor with others that operate at lower powers (in order to have an optimum motor loading, operating at high efficiency and high cosφ) and with higher speed (in order to have as small as possible motors). This solution requires also the modification of the pump foundation and is relatively expensive.

6.6 The pumps are replaced by others, corresponding to the Q and H values after metering. We highlight that, if the pump replacing is designed simultaneously or before the flow changing (as a consequence of the individual water consumption metering) and after the growing of the consumers which lead to higher flows, there is a risk to adopt pumps, even performant, but completely inappropriate if the Q and especially H values is not foreseen to be modified.

6.7 Converting the power supply of the driving motor must decrease the pump Speed. At a pumping station, pumping in parallel in the same network, it may be efficient to adjust the speed at one or maximum two pumps. The Speed adjustment of all the pumps is not efficient, being expensive and in this case, the overall efficiency of each pumping group is affected by the efficiency of converter and possible transformers.

6.8 There are new solutions, with the pumping groups of one or two machines [6], which provide the same opportunities as classical groups consisting of three machines, i.e., a motor, a mechanic speed reducer and a pump. The group consisting in a single machine is a mono-block aggregate including a pump, a gearbox and a motor. In the pumping groups with two machines, the new solution includes gearbox in pump or in motor. These solutions operate at constant speed, but are easily modifiable by (repeatable and reversible) replacing of two planet wheels. Unlike classical groups with three machines, at the new groups these modifications do not require disassembling of machines and alignments of the shafts. Further, these solutions have the following advantages:

- assure high overall efficiencies on large operating fields;
- easily adapting to the modified Q and H values toward the initial design;
- the existent motor and/or existing pump (but upgraded) can be reused sometimes;
- allow easier measuring of some parameters [7];
- for the group with mono-block aggregates, they have small size and weight, allow small foundations (as surface), do not require couplings, and all the alignment of the shafts are made by producer; at the beneficiary the aggregates are only settled to the foundation and the hydraulic and electric networks connections are made.

Note

In any pumping station, the optimal equipment can be a combination of the above solutions. Thus, e.g., any of the 6.1 to 6.6 and 6.8 solutions can be combined with the 6.7 solution (speed adjustment by frequency converting of the driving motor power supply for one to maximum two pumps, pump or pumps with adjustable speed totaling less than 30% of the pumping station power).

For any particular case where several solutions can be expected, the choice should be made based on a technical-economic calculation.

## 7. NEW SOLUTIONS AND OPERATING EQUIPMENT PUMPING STATIONS

### 7.1. Categories and types of pumping units expected

In the new solution pumping stations - PS is equipped with two types of pumping aggregates.

The first category includes aggregates with two different machines - pump and motor, coupled through a coupling: as a rule they have power and / or large debits, usually pumps with axial or single storey centrifugal pumps with double flux.

In turn, aggregates of the first category are of two types, namely conventional aggregates and aggregates new type of patented elements [7] or pending patent, having included a mechanical speed reducer or in the engine (especially at a axial pump aggregate, but possible with any other type of pump) or in pump (especially if it is a single storey double-flow centrifugal pump, but possibly with a other type pump).

The second category are mono block aggregates of a new type, with certificated elements [7] or pending patent, each mono block aggregate containing an high speed electric motor with a new building type, a two-speed mechanical gearbox steps (using gears in mass production of mechanical gear manufacturers) and a pump (typically single storey centrifuge with simple flux).

Pump hydraulic circuit components (draft tube, rotor, stator, spiral casing) may be taken from current production of series of pump manufacturers.

Aggregates in the second category, ie the mono block aggregate, stations are expected in particular for implementing the irrigation pressure. For the rest of PS (ie for basic PS and PS of repumping from irrigation, for PS draining and for PS from any other domain) optimal category and optimal type must be chosen from case to case.

In addition, to all PS that can be flooded, each pumping aggregate, of any category and type would be attached to an installation, with patentable elements, installation with which the installation working reliably and in submerged conditions, so even while the PS is flooded and in the next period of flooding of the PS. First aggregated features with such a system were tested successfully [10,11].

### 7.2. Specific functionalities of the new types of aggregates

All new type of aggregates, so both the mono block and those composed of two separate machines, one of these includes a mechanical speed reducers, too, has the following specific functionalities.

**7.2.1. Change functional characteristic curves**.

By changing the two gears (also facilitate the execution of the PS, without removing the aggregate) can change the pump speed, thereby changing the flow Q and the pumping height H according to requirements.

**7.2.2. Ensuring pumping with maximum possible** efficiency of the **pumps**

Possibility of adopting for pump any speed values (including much different engine speed possible) in all cases allow the adoption of the optimum value of rotor diameters D of pumps, ensuring operation with maximum efficiency and minimum installed power.

Consider the equipping of pumping stations - PS draining, which pump a flow $Q_{PS}$ = 22400 $m^3$/h at a pumping height H = 7m.

Classical solution (solution 0) has been described for this case, the chapter 4.

**Solution 1** (the new type aggregate). It adopts new type aggregates containing Brateş600 pumps, but with diameter $D=D_{max}$=672mm, ensuring maximum efficiency in the widest domain of flows.

Flow values Q, of pumping height H and efficiency η of 5 points characteristic curve type (drawing **AVERSA** no.M1311 D132) at D = 672mm and speed $n_0$ = 580rpm are played numerically in Table 1.

**Table 1. Flows Q, pumping heights H and efficiency η of Brateş600 pumps, n = 580 rpm, $D_1$ = 672 mm**

| No. order | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Q [$m^3$/h] | 1740 | 2860 | 3810 | 4190 | 4590 |
| H [m] | 17 | 15,6 | 12,3 | 10,2 | 6,9 |
| η [%] | 65 | 83 | 83 | 75 | 65 |

To new type aggregates pump can operate with any speed: meaning that the parameter values in Table 1 are calculated the same parameter values Q, H, at different speed $n_1$ with relations (6) (7 ), (8‘)and the results are played in Table 2 and Figure 1.

Finally result that, at the Brateş600 pumps D1 = 672 mm, H = 7m achieve maximum efficiency and maximum flow if is adopted the speed $n_1$ = 450 rpm. At this speed pumps present, according Figure 1:

- pump flow $Q_{P1}$ = 2800 $m^3$/h;
- pump efficiency $\eta_{p1}$ = 83%.

To make a fair comparison with the classical solution, which pumps are directly driven engine, takes into account that new types of aggregates were incorporated and a mechanical speed reducer with one or two steps.

**Tabel 2. Brateş600 pump with diameter D = 672 mm. Type characteristic curves at different speed $n_1$ = const. (by drawing AVERSA nr. M1311 D132)**

| $n_1$ rpm | Curve name Q-H in fig.1 | Order no. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| | | η(%) | 65 | 83 | 83 | 75 | 65 |
| 580 (600) | a | Q ($m^3$/h) | 1740 | 2860 | 3810 | 4190 | 4590 |
| | | H(m) | 17 | 15,6 | 12,3 | 10,2 | 6,9 |
| 550 | b | Q ($m^3$/h) | 1595 | 2621,667 | 3492,5 | 3840,833 | 4207,5 |
| | | H(m) | 14,285 | 13,108 | 10,335 | 8,571 | 5,798 |
| 490 (500) | c | Q ($m^3$/h) | 1450 | 2383,333 | 3175 | 3491,667 | 3825 |
| | | H(m) | 11,806 | 10,833 | 8,542 | 7,083 | 4,792 |
| 450 | d | Q ($m^3$/h) | 1305 | 2145 | 2857,5 | 3142,5 | 3442,5 |
| | | H(m) | 9,564 | 8,775 | 6,919 | 5,738 | 3,881 |
| 425 | e | Q ($m^3$/h) | 1232,5 | 2025,833 | 2698,75 | 2967,917 | 3251,25 |
| | | H(m) | 8,53 | 7,827 | 6,171 | 5,118 | 3,462 |
| 400 | f | Q ($m^3$/h) | 1160 | 1906,667 | 2540 | 2793,333 | 3060 |
| | | H(m) | 7,556 | 6,933 | 5,467 | 4,533 | 3,067 |
| 375 | g | Q ($m^3$/h) | 1087,5 | 1787,5 | 2381,25 | 2618,75 | 2868,75 |
| | | H(m) | 6,641 | 6,094 | 4,805 | 3,984 | 2,695 |
| 350 | h | Q ($m^3$/h) | 1015 | 1668,333 | 2222,5 | 2444,167 | 2677,5 |
| | | H(m) | 5,785 | 5,308 | 4,185 | 3,471 | 2,348 |
| 325 | i | Q ($m^3$/h) | 942,5 | 1549,167 | 2063,75 | 2269,58 | 2486,25 |
| | | H(m) | 4,988 | 4,577 | 3,609 | 2,993 | 2,024 |
| 300 | j | Q ($m^3$/h) | 870 | 1430 | 1905 | 2095 | 2295 |
| | | H(m) | 4,25 | 3,9 | 3,075 | 2,55 | 1,725 |

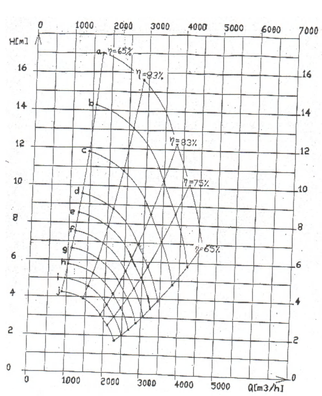


Fig.1. Brateş600 pump, $D_1$ = 672 mm, curves Q – H and efficiency curves at various speed $n_1$= const.

As every step renowned manufacturers of mechanical reducing ensure efficiency $\eta_s$ = 99%, efficiency on each pump from solution 1, ie $\eta_{p1}$, should be corrected to efficiency a maximum of two steps, becoming $\eta_{p+2s}$, ie:

$\eta_{p+2s} = \eta_{p1} \times \eta_s \times \eta_s$ = 83% x 0,99 x 0,99 = 81, 3483%.

The power at shaft engine will be so, according to equation (4):

$P_{shaft1}$ = 9,81 x $Q_{p1}$ x H / $\eta_{p+2s}$ = 9,81 x (2800 $m^3$/h : 3600 s/h) x 7m / 0,813483 = 65,656 kW

Coating is adopted engines with nominal pawer $P_{mot1}$ = 75 kW.

The pumping station, with eight such aggregates, we obtain:

- flow station $Q_{PS1} = 8 \times Q_{p1} = 8 \times 2800\ m^3/h = 22400\ m^3/h$;
- installed power station $P_{PS1} = 8 \times P_{mot1} = 8 \times 75kW = 600\ kW$;
- the difference in power over classical solution is $P_{PS} = P_{PS0} – P_{PS1} = 700kW – 600kW = 100\ kW$;
- the percentage difference of power $\Delta P_{PS\,\%} = \Delta P_{PS} \times 100 / P_{PS0} = 100 \times 100 / 700 = 14,2857\%$;
- pump efficiency taking into account gear $\eta_{p+2t} = 81,3483\%$;
- increase efficiency$\Delta\eta$ to the classical solution is $\Delta\eta = \eta_{p+2t} - \eta_{P0} = 81,3483\% - 70,7\% = 10,6483\%$.

It result that towards to the classical solution, the solution with a new type aggregate ensure the pumping station, the same flow $Q_{PS}$, at the same pumping height H, but with an efficiency gain (if the example above 10%) and allowing a lower installed power in station (if the instance with over 14%, ie less than 100 kW).

## 8. THE SOLUTION FOR THE PUMPING STATIONS THAT WERE FLOODED

### 8.1. Requirements for draining pumping stations

As shown [8], [9] more draining pumping stations - PSD were themselves flooded and removed from service even when their operation was strictly necessary. And rehabilitation of the classical solutions [9] has shortcomings, according to the chapter. 5 (is expensive, unreliable and with low overall efficiency).

Therefore seek a solution cheaper, more reliable and higher efficiency. Thus, the requirements were reworded electropumps of PSD and the PSD, namely:

- to pump reliable in dry PSD and temporary flooded PSD;
- PSD to pump with greater overall efficiency;
- PSD present sufficiently large installed flow, with updated values;
- adaptation to the first three requirements of existing or new PSD to cost as little as.

PSD rehabilitation new solution, with original elements, is to change the design of pumps and current our flood motors, to get electro pumps satisfying the four requirements. Solution is possible even if the corresponding change existing pumps and motors. Most of the 18 pumps flooded from Timis county, beeing Brateş 500, was made the first electro new type from an existing pump Brateş 500, modified by AVERSA Bucharest and an existing engine, modified at as in Transformers, Motors and Miscellaneous - TMD Filiasi [10], [11] resulting electro new model pump called Brates 500-500 - 510X, which can pump reliable in dry PSD and flooded PSD.

### 8.2. Samples bench of new type of pump

It was decided that the first two electro pumps Brateş500 -500 -510X equip an PSD that is H = 7.6 m and the required flow $Q_{nec} = 1,052\ m^3/s$.

The first copy, with relocated motor and relocated pump from other PSD, but new pump rotor of 560 mm neatly executed, to ensure high efficiency, was installed in stand AVERSA a test loop located in a dry basin but floating. Basin was flooded, during the electro-test being about 3 m below the water mirror.

Leak test the enclosure of the electric dry, air at about 2 bar, stating that it is absolutely watertight enclosure, started the electro pump and rose characteristic curves, played by a few points in Table 3.

Evidence showed that electro pump Brates 500-500 - 510X, obtained from a common pump and common motor, not floating, by corresponding changes, may temporarily submerged pump and ensure high efficiency (about 7% higher than those of Brateş 500 type of pump characteristics).

But because the optimum operating point does not correspond, PSD envisaged, requested corresponding decrease pump diameter. Decreased diameter D = 530mm, tests were repeated and new characteristics are played by a few points in Table 4.

Table 3. Electro pump Brateş 500 – 500 – 510X, n = 600 rpm, D = 560 mm

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Q($m^3$/h) | 2425,24 | 2297,81 | 2079,05 | 1323,20 | 890,706 | 572,962 |
| H(m) | 7,9538 | 8,5793 | 9,3055 | 11,0694 | 11,8427 | 11,3703 |
| η (%) | 86,778 | 89,982 | 89,177 | 72,901 | 53,908 | 35,858 |
| $P_{shaft}$(kW) | 60,5742 | 59,7005 | 59,1181 | 54,7498 | 53,3210 | 49,5083 |

Table 4. Electro pump Brateş 500 – 500 – 510X, n = 600 rpm, D = 530 mm

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Q($m^3$/h) | 2407,9 | 2078,9 | 1900,1 | 1639,5 | 987,5 |
| H(m) | 6,7 | 8,0 | 8,5 | 9,2 | 9,8 |
| η (%) | 86,37 | 89,39 | 88,2 | 85,6 | 58,6 |
| $P_{shaft}$(kW) | 50,94 | 50,75 | 49,90 | 48,02 | 45,00 |

Of the curve of Q - H obtained with the data in Table 4 at H = 7.6 m resulting in pump flow $Q_p = 2185\ m^3/h = 0,6069\ m^3/s$.

Of the curve η = f (Q) data obtained from Table 4 $Q_p$ value resulting pump efficiency η = 88.6%.

With two pumps in PSD also under consideration

is obtained at H = 7.6 m flow $Q_{PSD}$:

$Q_{PSD} = 2 \times Q_P = 2 \times 2185\ m^3/h = 4370\ m^3/h = 1,2138\ m^3/s > Q_{nec} = 1,052\ m^3/s$

QPSD reporting the required flow $Q_{nec}$ resulting: $Q_{PSD} / Q_{nec} = 1,2138 / 1,052 = 1,1538$.

So with such two electro pumps in PSD ensures a flow of over 15% higher than the required flow $Q_{nec}$, without installing any additional pump.

## 9. CONCLUSIONS

a) Through incentives, water consumption metering ensures normal specific consumption of 80-150 l/capita day.

b) In the countries of Eastern Europe, the metering generalization was delayed and, consequently, the specific consumption increased even up to 500 l/capita day [1], increasing water flow Q and Speed v in pipelines, hydraulic losses $h_r$, pumping heads H required by the pumps, powers P and energies E consumed by pumps. Obviously, the adoption of appropriate pumps is required.

c) In the places where the metering was introduced after the specific consumption reached high levels, this consumption decreased to normal levels and once with consumption, the Q, v, $h_r$ and H values also decreased, e.g., in a particular case H decreased from 58 m to below 25 m. Thus, a new problem emerged, i.e., the malfunction of the pumps adopted to operate at high H values, by operating at low H values.

d) In many existing draining pumping stations it was found that the required values of maximum flow $Q_{max}$ and pumping heights H differs significantly from the values adopted in the design of these stations.

e) In some pumping stations equipped with centrifugal pumps directly driven engine, to get the required values $Q_{max}$ and H, it must be adopt a value D values of diameter pump different from the optimal value $D_{opt}$ and therefore these stations require higher installed power and pumped with efficiency lower than where it is possible to adopt $D = D_{opt}$.

f) Electro pumps from many draining pumping stations can pump only if the pumps are dry, and if stations are flooded electro pumps cannot pump.

g) New problems listed above, have generated design new original technical solutions [6], [7], [10], [11], which may be optimal in many cases.

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