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HYDRAULIC CALCULATION SCHEME OF AN IRRIGATION PRESSURE SYSTEM FEEDING TWO RESERVOIRS OPERATING AT DIFFERENT ALTITUDES (BASED ON THE EXAMPLE OF THE KAMARIS-GEGHASHEN IRRIGATION SYSTEM)

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Abstract

The pumping station that was constructed in the middle of the 20th century within the boundaries of the city of Abovyan, Republic of Armenia, was designed to feed irrigation

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water to the 280 ha of community land owned by the villages of Geghashen and Kamaris. It hasn't functioned for many years now, for it has been entirely disassembled. In order to guarantee the simultaneous feeding of two reservoirs located at various altitudes, an issue was configured to restart the pumping station.
This article provides an example of the Kamaris-Geghashen system using the hydraulic calculation technique of an irrigation pressure system feeding two reservoirs at various altitudes.

***Keywords*:** water, soil, filtration, polymer-mineral material, sand clay.

Introduction

Centrifugal pumps account for 80% of all pumps and it is a known fact that most centrifugal pumps have an overcapacity of 20–30%. It has been calculated that the energy wasted by all the pumps operating at present in the EC is 46 TWh on a yearly basis [1].

Improving the efficiency and reliability of the regulation of centrifugal pumps installations of low and medium power is especially important in water supply systems with a variable component of the load, for example, in irrigation systems and in systems with a small static head. It has been established that sliding the operating point of pumps along the pressure-flow characteristic of the pipeline is the most effective method of controlling adjustable centrifugal pumps [2,3].

Of course the associated pump manufacturers are doing their best to develop new pumps with a higher efficiency rate. But in many cases it turns out that the largest energy saving can be achieved by simply improving the installation design. Pumps are usually used to make fluids flow through pipes by an increase in pressure. This is mostly the case when we want to transport fluids in storage or in production systems from one place to another. The differential head that the pump has to bridge, not taking into account the flow losses within the system, consists of the counterpressure and the vertical difference in height. A pump will always have to bridge the difference between the lower suction-side pressure and the higher discharge-side pressure. Of course, any such units need to meet our requirements. They should be neither too small nor too large [1].

Two 3B-200x4 high-pressure pumping units were installed in the building of the pumping station, one of which - as a hot spare.

Fig. 1 shows the plan and side view of the pumping station's structures.

Irrigation water was supplied by pressure derivation (1) to the accumulation regulating basin (2), from where the water was supplied to the receiving basin (4) of the pumping station through a metal pipe (3).

The static pressure of the pumping station was 188 m, the pumping output was 110 l/s. The injection pipeline ABC is buried, the length is 2718 m, the diameter is 300 mm along the entire length.

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Water level marks in the reception basin (1485 m), upper pressure basin (1673 m), intermediate pressure basin (1632 m), and the length main delivery pipeline segments (AB - 2070 m, BC - 648 m, BD - 125 m) constitute the baseline data.

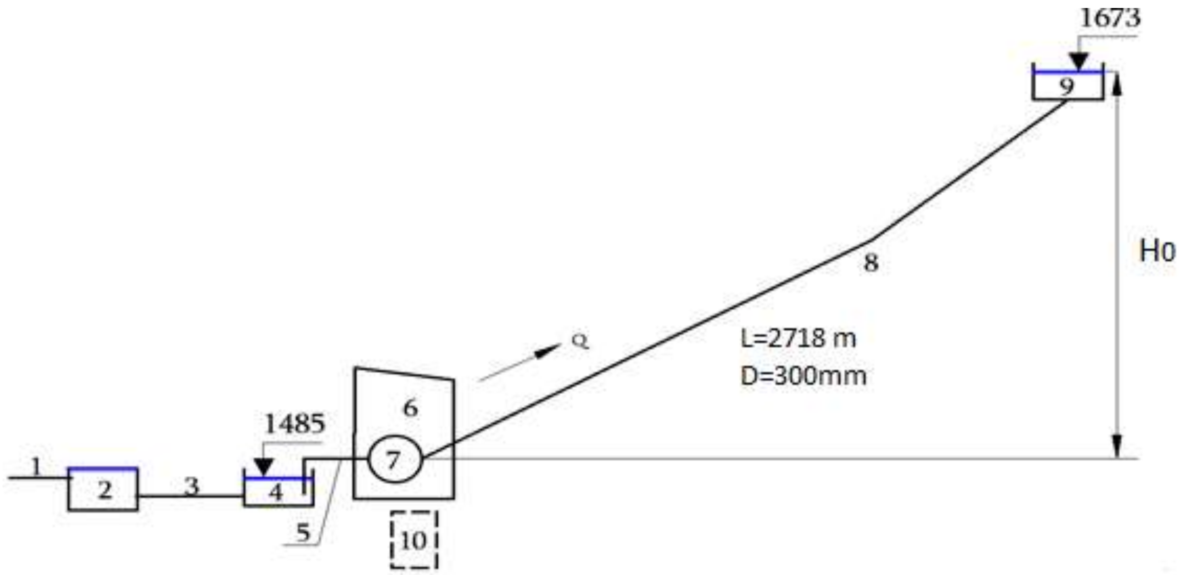

Fig. 1 Schematic plan of the pumping station
1. pressure derivation, 2. regulating/equalizing basin of concrete rectangular cross-section
3. metal pipe d=800 4. prismatic receiving basin of concrete rectangular cross-section
5. suction pipe -d=300 mm, 6. machiery hall 7. pump, 8. delivery pipeline
9. pressure separator basin, 10 transformer

The pipeline segments of the main delivery line, AB, BC, and BD, are of diameters of 300 mm, 250 mm, and 300 mm, respectively.

Conflict Setting

Using one pump unit to simultaneously supply water to two swimming pools at different heights is a challenging task. The goal is to develop a calculation scheme to solve this problem.

Research Results

The hydraulic resistances (S) of the thrust pipeline sections will be: SAB=2070/1,065= 1943, SBC= 648/1,065=608 , SBD =100/0,3871=258 (s2/m5). The value of $(S_i = \frac{l_i}{K_i^2})$, K_i^2 for metallic pipe has been taken from a table according to the inner diameter of the pipe.

Operating mode of the pump unit: A: Separate pumping to the upper pressure basin (BD water line valve closed, BC water line valve open). The total hydraulic resistance (S_0) of the waterline will be

$$S_0 = S_{AB}+S_{BC} =1943+608 = 2551 \text{ s}^2/\text{m}^5. \quad (1)$$

Table 1

H_0=188m, S_0=2551 s^2/m^5

Q, m^3/s	0,04	0,06	0,08	0,1	0,12
S_0Q^2, m	4,08	9,18	16,0	26	37
H, m	192,21	197,2	204	214	225
Hp			240	220	215

The geodetic pressure head H_0 (static pressure) will be: H_0 =1673-1485=188m, and the pipeline characteristic equation - H=f(Q); $H=H_0+S_0Q^2$.

Tab. 1 shows the coordinates of the characteristic curve of the pipeline ABC.

The coordinates of the operating mode's point only in the case of pumping into the upper basin are given in Fig. 2.

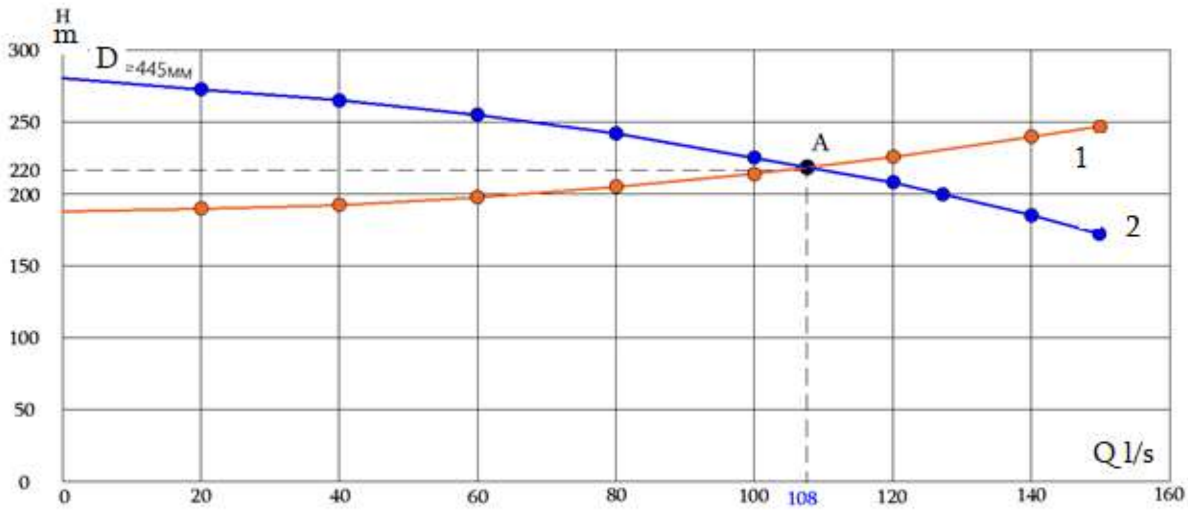

Fig. 2 Coordinates of the operating mode's point only in the case of pumping into the upper basin (1 - main characteristic of the pump, 2 - characteristic of the ABC pipeline)

The working mode of the pump unit: B. Separated: pump intermediate pressure basin (BD water line valve is open, BC water line valve - closed)

The total hydraulic resistance (S_0) of the water line will be:

$$S_0 = S_{AB}+S_{BD} =1943+258 = 2201\ s^2/m^5. \quad (2)$$

The geodetic pressure head H_0 of the water line (static pressure) will be: H_0 =1632-1485=147m. Tab. 2 shows the coordinates of the ABD pipeline characteristic curve. The coordinates of the operating mode's point only in the case of pumping into the intermediate pressure basin are given in Fig.3.

The operating mode of the pump unit: C. joint operating mode (BD water line valve is open, BC water line valve - open).

When choosing the option for the joint operation of the pipeline ABC and the branch BD, it is necessary to reduce the diameter of the branch BD, because its thrust geodetic height is noticeably smaller than the geodetic height of the main water line.

It is advisable to choose the diameter of the branch according to the proportion of the surface areas of the upper and intermediate basins.

Table 2

H_0=147m, S_0=2201 s^2/m^5 d_{AB}=250 mm

Q m^3/s	0,04	0,06	0,08	0,1	0,12	0,13	0,14	0.15
S_0Q^2, m	3,52	7,92	14,0	22,0	32	37	43	50
H, m	151	155	161	169	179	184	190	197
Hp				220	215	198	185	175

It is advisable to choose the diameter of the branch according to the proportion of the surface areas of the upper and intermediate basins.

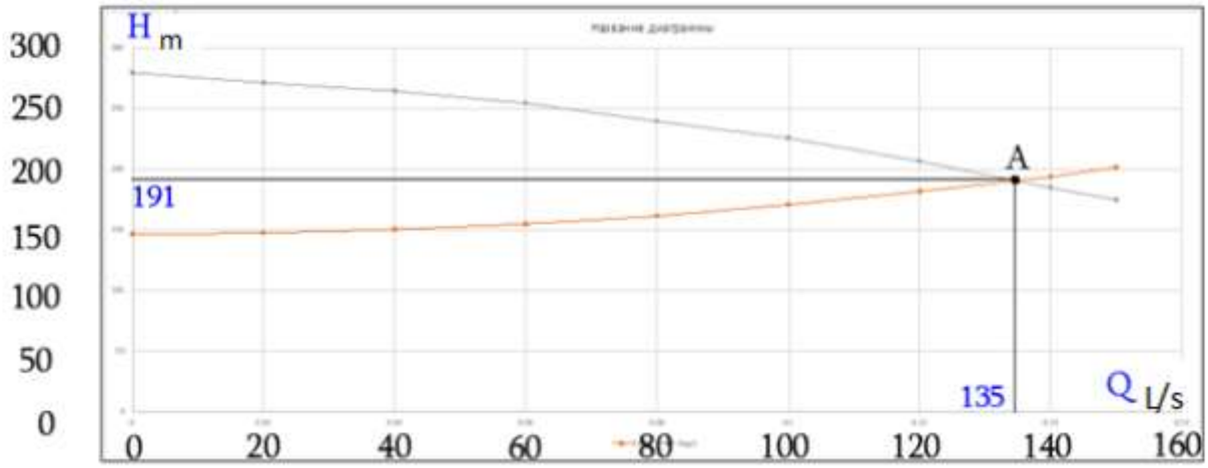

Fig. 3 Coordinates of the operating mode's point only in case of pumping into the intermediate basin

According to the operation requirements, the surface areas of the irrigated lands under the upper and intermediate basins are 130 and 170 ha, respectively. Therefore the output fractions Q driven will be 0.43Q and 0.57Q respectively. Let's determine the magnitude of the output Q driven by the pump. The mark of the piezometric line of the cross-section of the unit B of the branch connection to the highway pipeline will be:

$$H_B = H_0 + S_{BC}\,(0,43Q)^2 = 188 + 628x0,432Q^2 = 188 + 116Q^2. \qquad (3)$$

On the other hand, according to Shezi's formula, we have:

$$H_B - H_1 = S_{BD}(0,57Q)^2 = 0,325 S_{BD} Q^2, \qquad (4)$$

where H1=147 m is the water level mark in the intermediate basin, SBD is the hydraulic resistance of the small diameter branch pipe.

$$(0{,}325S_{BD} - 116)Q^2 = 41. \qquad (5)$$

The choice of the diameter of the branch should be made so that its hydraulic resistance has such a magnitude that the output Q determined from equation (5) is in the optimal range of output variation (80...140 l/s) and the pressure H is less than or equal to the main characteristic of the pump. Hp from the pressure, i.e. $H \leq Hp$.

Let's choose the diameter of the branch dBD=125mm. In that case, the hydraulic resistance of the water line of the branch will be: $S_{BD} = L_{BD} / K^2$, (K^2=0,012150 m^6/s^2), S_{BD} =100/0,012150=8230 s^2/m^5.

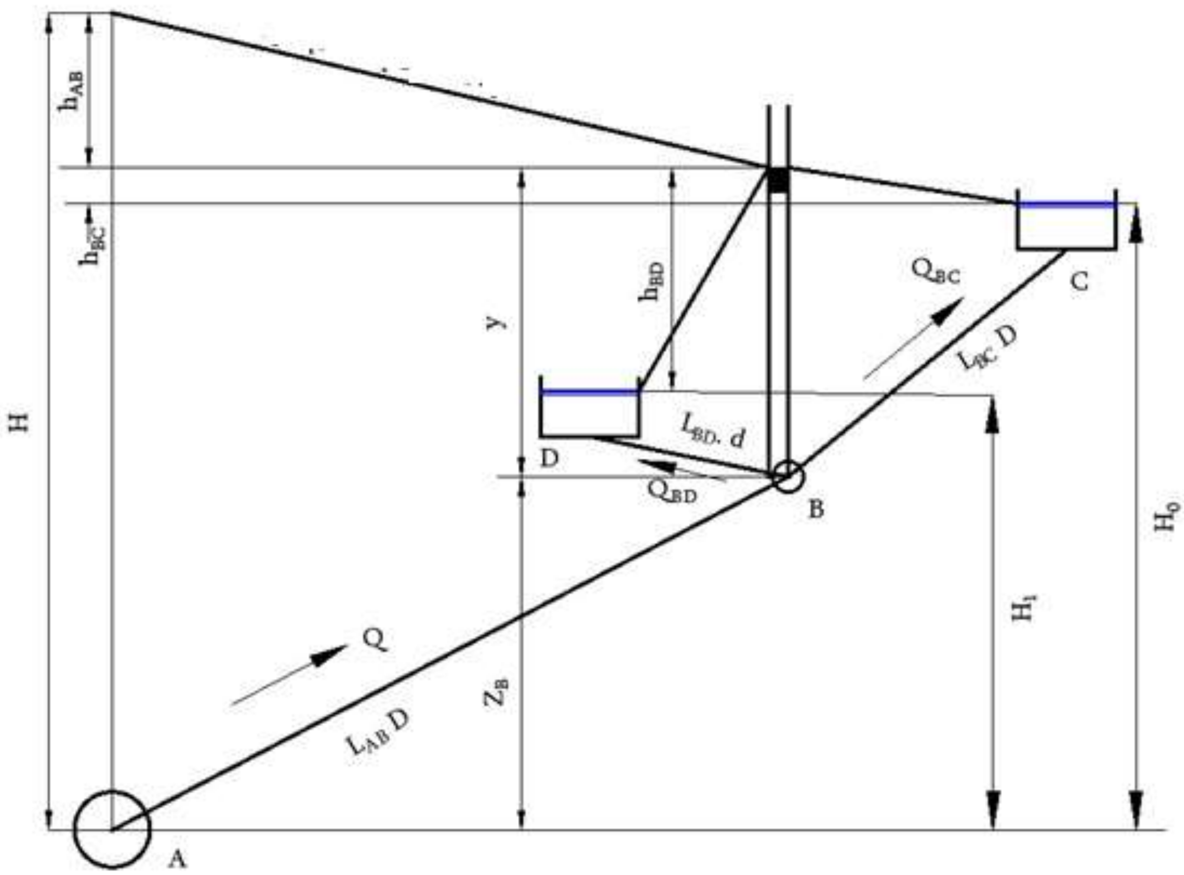

Fig.3 Hydraulic scheme of the joint operation of the system

Substituting the value of S_{BD} into Eq.(5) we get: Q=0,127 m^3/վ = 127l/s. Obviously, this output will be the output through section AB of the main pipeline, i.e. $Q=Q_{AB}$=127 l/s.

It can be seen from the characteristics of the pump that the coefficient of efficiency is $\eta = 0{,}75$

It turned out that BC and BD are released simultaneously through the water lines, respectively Q_{BC}=0,43Q=55 l/s , Q_{BD} =0,57Q=72 l/s outputs.

The magnitude of the required pressure H at the lower end section of the main pipeline will be determined bybelow equation

$$H=H_0 +S_{AB} Q^2+S_{BC}Q^2_{BC} \qquad (6)$$

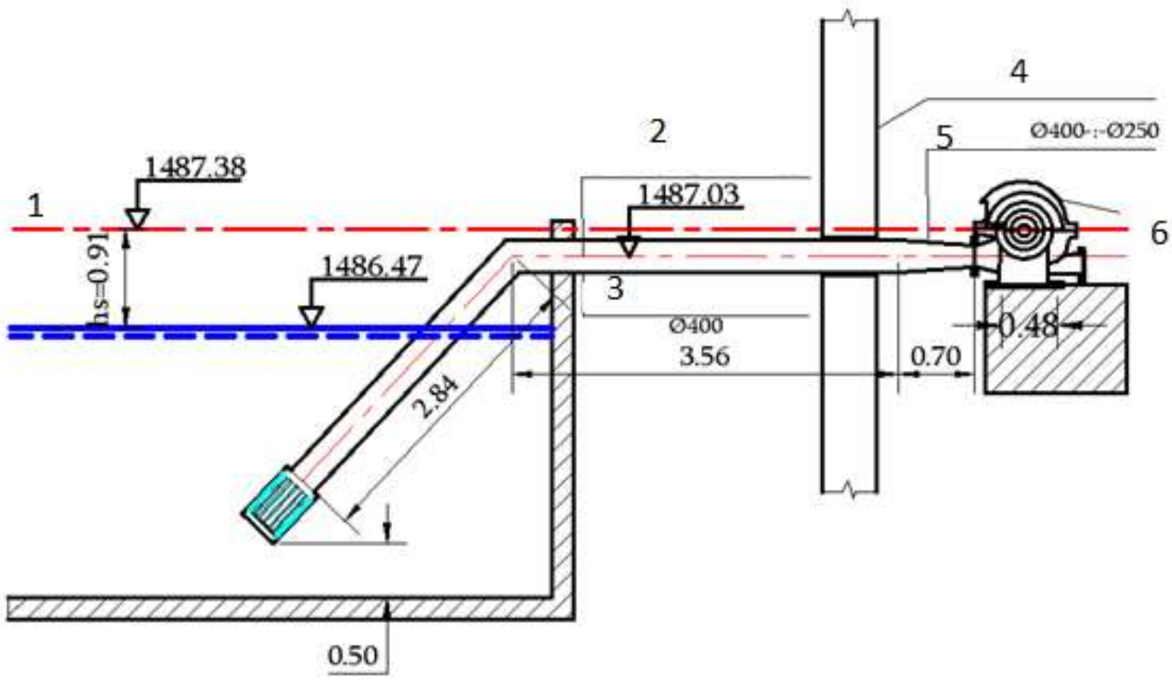

Fig. 4 Hydraulic scheme of the pump unit

1- axis of the pump's shaft, 2- pipe's axis, 3- suction pipe, 4- wall of the gallery, 5- diffuser, 6-pump

It is expedient to determine the coordinates of the point of the hydraulic working mode, which is established in the case of simultaneous water supply, graphically.

Conclusion

1. To theoretically address the problem of pumping liquid into basins of different altitudes with a pump, it is necessary to approximate the curve of the primary characteristics of the pump with a square parabola. Then, four equations containing four unknowns are produced.

2. Otherwise there will be an infinite number of solutions and, therefore, answers. The answer that corresponds to Q and has the highest GPA is chosen. After determining Q, it is customary to determine the required pressure H that will be established at the lower end of the pipeline. The determined pressure is matched with the developed pressure of the pump, Hp. If the resulting comparison shows that H is very close to Hp, the problem is considered solved. It is advisable to solve this problem graphically.

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References

1. Vogelesang Hans. An introduction to energy consumption in pumps //World pumps. 2008, № 496, pp. 28-31.
2. Muravev A.V., Kalinin A.G., Myasnikova T.W. Control of energy-saving modes of pumping units according to the “power balance” criterion //Bulletin of Chuvash State University, 2019, N1, pp. 75-82.
3. Pete Noll. Determining the real cost of powering a pump //World Pumps.2008, vol.2008, № 496, pp. 32-34.

References

1. Vogelesang Hans. An introduction to energy consumption in pumps //World pumps. 2008, № 496, pp. 28-31.
2. Муравьев А.В., Калинин А.Г., Мясникова Т.В. Управление энергосберегающими режимами насосных установок по критерию «баланс мощности» //Вестник Чувашского университета, 2019, № 1, с. 75–82.
3. Pete Noll. Determining the real cost of powering a pump //World Pumps.2008, vol.2008, № 496, p. 32-34.

ՏԱՐԲԵՐ ԲԱՐՁՐՈՒԹՅԱՆ ԵՐԿՈՒ ԱՎԱԶԱՆՆԵՐ ՍՆՈՂ ՈՌՈԳՄԱՆ ՃՆՇՈՒՄԱՅԻՆ ՀԱՄԱԿԱՐԳԻ ԱՇԽԱՏԱՆՔԻ ՀԻԴՐԱՎԼԻԿԱԿԱՆ ՀԱՇՎԱՐԿԻ ՍԽԵՄԱ (ԿԱՄԱՐԻՍ-ԳԵՂԱՇԵՆ ՈՌՈԳՄԱՆ ՀԱՄԱԿԱՐԳԻ ՕՐԻՆԱԿՈՎ)

Ա.Յա. Մարգարյան, **Գ.Հ. Մարտիրոսյան**, **Դ.Վ. Մադոյան**, **Վ.Հ. Թոքմաջյան**
Ակադեմիկոս Ի.Վ. եղիազարովի անվան ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտ

Հայաստանի Հանրապետության Աբովան քաղաքի տարածքում է գտնվում Գեղաշեն և Կամարիս գյուղերի 280 հա մակերեսով համայնքային հողատարածքներին ոռոգման ջուր մատակարարելու նպատակով, 20-րդ դարի կեսերին կառուցված պոմպային կայանը: Այն ամբողջովին ապամոնտաժված է և երկար տարիներ չի գործում: Խնդիր է դրվել վերագործարկել պոմպակայանն՝ ապահովելով տարբեր բարձրությունների վրա գտնվող երկու ավազանների միաժամանակյա սնումը: Հոդվածում Կամարիս-Գեղաշեն համակարգի օրինակով բերվում է տարբեր բարձրության երկու ավազաններ սնող ոռոգման ճնշումային համակարգի աշխատանքի հիդրավլիկական հաշվարկի սխեման:

Բանալի բառեր. ջուր, պոմպ, հողատարածք, խողովակ, դերիվացիա, ճնշման ավազան

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ГИДРАВЛИЧЕСКАЯ РАСЧЕТНАЯ СХЕМА РАБОТЫ ОРОСИТЕЛЬНОЙ НАПОРНОЙ СИСТЕМЫ, ПОДАЮЩЕЙ ВОДУ В ДВА БАССЕЙНА НА РАЗНЫХ ВЫСОТАХ (НА ПРИМЕРЕ ИРРИГАЦИОННОЙ СИСТЕМЫ КАМАРИС-ГЕГАШЕН)

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Насосная станция, построенная в середине 20-го века с целью подачи оросительной воды на 280 га общинных земель сел Гегашен и Камарис, расположена на территории города Абовян Республики Армения. Она полностью демонтирована и не работает уже много лет. Была поставлена задача перезапустить насосную станцию, обеспечив одновременное питание двух бассейнов, расположенных на разных высотах.

В статье на примере оросительной системы Камарис-Гегашен приведена гидравлическая расчетная схема напорной системы, одновременно питающей два бассейна.

Ключевые слова: вода, насос, земляной участок, труба, деривация, напорный бассейн.

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