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Simulation of the Movement of the Ground Water in a Rectangular Jumper with a Screen

Bereslavskii Eduard Naumovich*

Saint Petersburg, State University of Civil Aviation, Russia

1. Abstract

As part of the flat established filtration of the incompressible liquid, Darcy's law gives an accurate analytical solution to the problem of current in a rectangular jumper with a screen in the presence of evaporation from the free surface of groundwater. There are marginal cases of the movement in question - filtering in a low-pressure layer to an imperfect gallery, as well as the current in the absence of evaporation.

2. Introduction

Solving the problem of fluid inflow to an imperfect well with a flooded filter (i.e., an ossymmetrical problem) in an accurate hydrodynamic setting is associated with great mathematical difficulties (especially for currents with a free surface) and until now there are no [7] [1-6] (there are not considered numerous numerical and approximate solutions). Therefore, as the first approach to the solution of this problem were considered ,1.5-8) its flat analogues - the problem of the flow of liquid to the rectangular jumper with a screen and to the imperfect straight gallery, which give a certain qualitative idea of the possible dependence of filtration characteristics on the degree of the well's insularity [1 – 10]. The paper provides an accurate analytical solution to the problem of the movement of groundwater in a low pressure layer to an imperfect gallery in the presence of evaporation from a free surface. It is shown that the picture of the current near the impenetrable screen significantly depends not only on the imperfection of the gallery, but also on the presence of evaporation, which strongly affects the expense of the gallery and residents of the point of exit of the depression curve on the impenetrable wall.

The presented work gives an accurate solution to the problem of filtration in a rectangular jumper with a screen in the presence of evaporation from the free surface of groundwater. In this case, as in the "9" (as opposed to the"7, 8") in the field of the 10ograph flow speed there are not straight- but circular polygons, which does not allow to use the classical formula of Kristoffel-Schwartz. Using the special-view methods developed for areas of the special view, the mixed multi-parametric edge task of the theory of analytical functions is solved by the methods of conforming of circular polygons. Taking into account the characteristics of the current in question allows to get a solution through elementary functions, which makes Bereslavskii Eduard Naumovich. Simulation of the Movement of the Ground Water in a Rectangular

***Corresponding author:** Bereslavskii Eduard Naumovich, Saint Petersburg State University of Civil Aviation, Russia, Email: eduber@mail.ru

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their use the most simple and convenient.

1. Figure 1 shows a rectangular jumper with slopes A_0A_1 and D_0B on the impenetrable horizontal base of

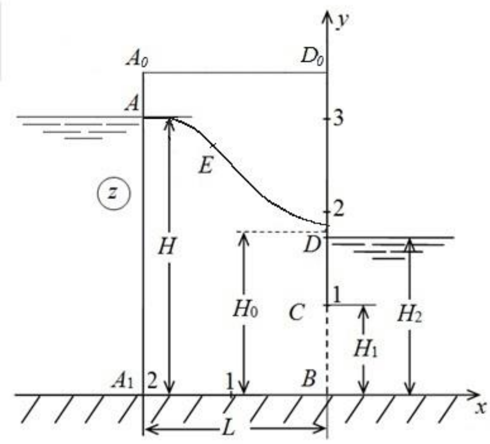

Figure 1: A picture of the current in a rectangular jumper with a screen, calculated at the ε 0. 5, H = 3, L = 2, H1 = 1, H2 = 1. 4.

L length. H_2 zgt; H_1, the usual for dams no drop-off gap ε ε is missing.

We will introduce a complex potential of movement φiψ, where the speed potential, current function and complex coordinate are assigned respectively to κH and H, where H - pressure at point A. When indicated in Figure 1 of the choice of the coordinate system and the combination of the plane comparing the pressures with the plane yq0 at the border of the filtration area are performed the following edge conditions:

$$AD: \varphi = -y, \psi = -\varepsilon x + Q; DC: x = 0, \psi = Q; CB: x = 0, \varphi = -H_2; BA_1: y = 0, \psi = 0; A_1A: \varphi = -H, x = -L. \quad (1)$$

The challenge is to determine the position of the free AD surface and to find the H_0 residency point of the depression curve on the screen, as well as the filtering flow of the value.

2. We use the P.Y. method to solve the problem. Semibarinova-Kochina, which is based on the application ζ ζ of the analytical theory of linear differential equations of the ζ ζFuchs class. ζ_Ee, ζ_Aq1, ζ_{A1},a_1, ζ_B,B,(a_1, b - unknown affixes of points A_1 and B in the plane ζ), ζ_C∞,as well as functions dw / dζ and dz / dζ.

By determining the characteristic performance of the functions of dw /d ζ and dz /d ζ near regular special points, we will find that they are linear combinations of the two branches of the trace of the Riemann's 1, 6, 14 function:

$$P\begin{Bmatrix} 0 & e & 1 & \zeta_A & \zeta_B & \infty & \\ 0 & 0 & -\frac{1+\nu}{2} & -\frac{1}{2} & -\frac{1}{2} & \frac{3}{2} & \zeta \\ -\frac{1}{2} & 2 & -\frac{1-\nu}{2} & \frac{1}{2} & \frac{1}{2} & 2 & \end{Bmatrix} = \frac{Y}{\sqrt{\zeta(1-\zeta)^{1+\nu}(\zeta_A-\zeta)(\zeta_B-\zeta)}}, \quad (2)$$

$$Y = P\begin{Bmatrix} 0 & e & 1 & \infty \\ 0 & 0 & 0 & -\frac{1+\nu}{2} \\ \frac{1}{2} & 2 & \nu & -\frac{\nu}{2} \end{Bmatrix}$$

Where is. The last symbol of Riman corresponds to the following linear differential equation of the Fuchs class with four regular special points:$\nu\pi = 2\mathrm{arctg}\sqrt{\varepsilon}$

$$Y'' + \left(\frac{1}{2\zeta} + \frac{1-\nu}{\zeta-1} - \frac{1}{\zeta-e}\right)Y' + \frac{\nu(1+\nu)\zeta+\lambda}{4\zeta(\zeta-1)(\zeta-e)}Y = 0 \quad (3)$$

It is well known that when integrating equations of this kind, there are fundamental difficulties.

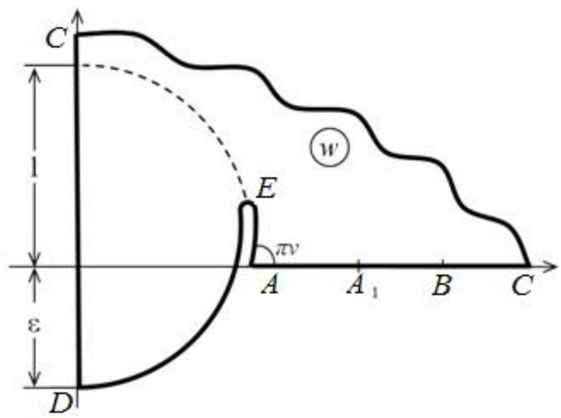

Figure 2: Integrated speed area *w*.

Let's turn to the area of complex speed w, corresponding to boundary conditions (1), which is depicted in rice. 2. This area, which is an ABCDE circular quadrangle with a cut to the top at point E (appropriate point of inflection of the depression curve) and an angle of the A, belongs to the class of circular polygons in the polar grids and has been researched before [11 – 6]. It is important to emphasize that such areas, despite their private appearance, are however very typical and are typical for many tasks of underground hydromechanics: when filtering from canals, irrigation and reservoirs, in the currents of fresh water over the resting salt waters, in the tasks of wrapping the spool of Shchukovskiy in the presence of salty retaining waters (see for example 11-15").

Replacing variables ζ th 2t translates the upper half-flat ζ into the horizontal semi-strip Re tzgt;0, 0'lt;I'm tzlt'0.5" parametric plane t according to t A points∞, tDq0, tC,t0.5, tBqarcthq0.5, $\sqrt{b}$ tA1qarcthq 0.5' (1 zlt; $\sqrt{a_1}$ a1zlt;bqlt;∞), and integrals Y equation (3), which are constructed by the method of "13" converts to the view of the

$$Y_1 = \frac{\mathrm{ch}t\mathrm{ch}\nu t + C\mathrm{sh}t\mathrm{sh}\nu t}{\mathrm{ch}^{1+\nu}t}, \quad Y_2 = \frac{\mathrm{ch}t\mathrm{sh}\nu t + C\mathrm{sh}t\mathrm{ch}\nu t}{\mathrm{ch}^{1+\nu}t} \tag{4}$$

where C (C≠1) is an unknown suitable constant.

Taking into account the ratio (2) and considering that wqdw/dz, come to the addictions we are considering

$$\frac{d\omega}{dt} = iM\frac{\sqrt{\varepsilon}(chtchvt + Cshtshvt) + i(chtshvt + Cshtchvt)}{\Delta(t)},$$

$$dz/dt = -M/\sqrt{\varepsilon}\ (chtchvt + Cshtshvt - i\sqrt{\varepsilon}(chtshvt + Cshtchvt))/(\Delta(t)),$$

$$\Delta(t) = \sqrt{[(a_1-1)sh^2t + a_1][(b-1)sh^2t + b]},$$

(5)

where Mis a large-scale constant simulation.

You can verify that the functions (5) meet the boundary conditions (1) that are reformulated in terms of functions dw/dt and dz/dt, and thus are a parametric solution to the original edge task.

The result is expressions for the given values: the width of the L jumper, the level of its water in the upper H and the lower H_2 beefs and the length of the H_1 filter.

$$\int_0^\infty X_{DA}(t)dt = L, \int_{\mathrm{arcth}\sqrt{a_1}}^\infty Y_{AA_1}(t)dt = H, \int_0^{0.5\pi}[\Phi_{DC}(t) + Y_{DC}(t)]dt + H_1 = H_2, \int_0^{\mathrm{arcth}\sqrt{b}} Y_{CB}(t)dt = H_1, \tag{6}$$

the points of the AD free surface points

$$x(t) = -\int_0^t X_{DA}(t)dt, y(t) = H_0 - \int_0^t Y_{DA}(t)dt \tag{7}$$

and expressions for filtering flow value and residents of the free surface exit point on the screen

$$Q = \int_0^{\mathrm{arcth}\sqrt{b}} \Psi_{CB}(t)dt, H_0 = H - \int_0^\infty \Phi_{DA}(t)dt. \tag{8}$$

Other expressions for the values of H_0 and L are used to control calculations:

$$Q = -\varepsilon L + \int_{\mathrm{arcth}\sqrt{a_1}}^\infty \Psi_{AA_1}(t)dt,$$

$$H_0 = H_2 - \int_0^{0.5\pi}\Phi_{DC}(t)dt, H_0 = H_1 + \int_0^{0.5\pi} Y_{DC}(t)dt, \tag{9}$$

$$L = \int_{\mathrm{arcth}\sqrt{b}}^{\mathrm{arcth}\sqrt{a_1}} X_{BA_1}(t)dt,$$

as well as the expression

$$\int_0^\infty \Phi_{DA}(t)dt - \int_0^{0.5\pi}\Phi_{DC}(t)dt - \int_{\mathrm{arcth}\sqrt{b}}^{\mathrm{arcth}\sqrt{a_1}} \Phi_{BA_1}(t)dt. \tag{10}$$

directly arising from the boundary conditions (1).

In formulas (5)- (10) subtegrial functions - expressions of the right parts of equals (3) on the corresponding sections of the contour of the auxiliary area t.

Limit cases

1. At L→∞, i.e., when points A_1 and A are merged, in plane t, i.e., at a_1→1 (arch a_1∞) the jumper degenerates into a semi-bottomed left no-pressure layer.

2. When ε→0, i.e., at low evaporation intensity values, the results of the work are obtained.

3. Views (5) - (10) contain four unknown permanent M, C, 1 and b. Options a 1, b (1 qlt; a ≠ 1 qlt; b qlt; ∞), C (C 1) are defined from equations (6) for the H 1, H_2 (H_1 ≤ H_2 lt) H) and L, the constant modeling of M at the same time is from the second equation (6), fixing the level of H water in the upper beef of the jumper.

On rice. 1 shows a picture of the current, calculated at ε q 0.5, H q 3, L q2, H 1. 1.0, H_2 q 1.4 (basic version of the "9"). Results of calculations of the effect of the defining physical parameters of the ε, H, H_1, H_2 and L on the values q and H_0 are given in the table 1, 2.

Table 1: The results of calculations of the values of z and H_0 at the variation of ε, H and L.

E	Q	H_0	H	Q	H_0	L	Q	H_0
0.1	1.3937	2.3003	2.5	0,5624	14,074	1.5	1.6261	2.1424
0.2	1.3423	2.1544	3	11,554	17,750	1,7	18,970	13,492
0.3	1.2839	2.0179	3.5	15,715	20,883	2	1.1554	1.7755
0.4	1.2218	1.892	4.5	26,811	33,097	2.5	0.7585	1.5045
0.5	1.1554	1.7755	5	29,726	37,528	2.9	0.4863	1.3727

Table 2: H1 and H_2.

H_1	Q	H_0	H_2	Q	H_0
0.9	1.112	1.8292	1.09	1.3965	1.5533
1	1.1554	1.7755	1.19	1.3627	1.5775
1.1	1.1928	1.7161	1.29	1.2425	1.7051
1.2	1.2235	1.6494	1.39	1.1598	1.7695
1.3	1.246	1.5728	1.4	1.1634	1.7694

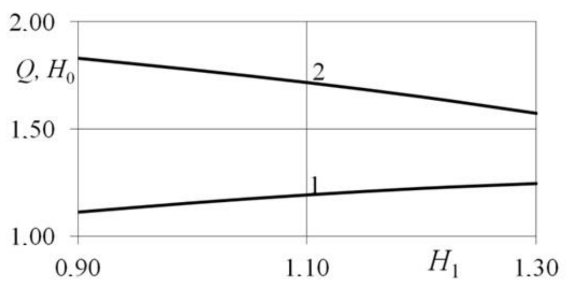

Figure 3: The flow of the *jumper* and the H_0 exit point of the free H_0 surface from the length of the H_1 filter.

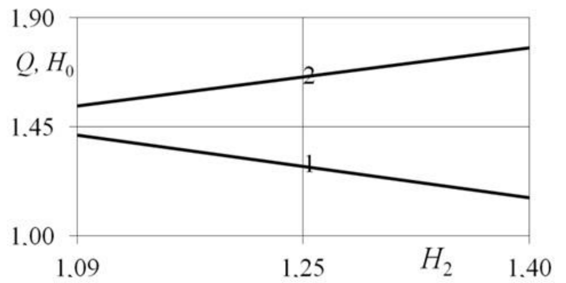

Figure 4: The dependence of the flow of the jumper and the residents H_0 point of exit of the free surface from the water level in the lower
beef H_2.

Figure 3 and 4 feature consumption dependence (curves 1) and residents H_0 point of exit of the depression curve on the screen (curves 2) from H $_1$ and H_2. Analysis of the calculations of these tables and graphs of poses is to draw the following conclusions:

- Reducing the evaporation intensity of ε and increasing H pressure accompany an increase in the flow of H and residents H_0 point of exit of the depression curve on the screen;

- Reducing the depth of the H_1 screen and increasing the water level in the lower beef H_2 is accompanied by a decrease in the flow of the H 0 and an increase in the residency of H_0;

-- with the width of the L jumper, the expense of the L and the residency H_0 of the free surface exit point on the screen decreases.

From the table. 2 and Figure 3, 4 Follows that a reduction in H_1 and H_2 respectively, in 1.5 and 1.3 times, results in a change in the value of the value of the Q by 16.8% (when fixing H_1) and12% (when fixing H_2).

The basic version of almost all the dependencies of the values of q and H_0 on the parameters of ε, H, H_1, H_2 and L are close to linear.

A comparison of the exact values obtained for the baseline version of the q1,155 and H_0q1.776 with the approximates of q1.141 and H_0q1.768 for the baseline version, where the current area on the left was limited to the expression, showing that the relative error of the calculations is very small and is only 0.5 and 1.3% respectively.

A comparison of the exact cost value of the 1.16 received for the baseline version with the approximate value of z1.26, which occurs when you apply the generalized formula of I.A. Charny.1,c. 267) for a conventional rectangular jumper (without a screen) if there is evaporation

$$Q = -\frac{\varepsilon L}{2} + \frac{H^2 - H_2^2}{2L},$$

leads to a margin of error of 8.3%.

For comparison with the data H1, H_1 q0.05, H_2 q0.238, Lq4 pabota (7)in the absence of evaporation, i.e. in the ε of 0, for which the approximate formulas in the semi-reversible production received values of0.118, H_0q 0.29, consider the variant of the ε of 0.1, H q1, H 1 q0.05, consider the variant of the ε of 0.1, H q1, H 1 q 0.05, consider the variant of the ε of 0.1, H q1, H 1 q0.05, consider the variant of the ε of0.1, H q1, H1q 0.05, consider the variant of the ε 0.1, H q1, 0.05, H_2 q0.238, Lq4, leading to exact values of q0.42, H_0 q0.75. Here the relative errors of computation are 71 and 61% respectively.

4. The study shows that the scheme of filtration in a rectangular jumper with an impenetrable screen is very similar to the task of moving groundwater to an imperfect gallery. And one of them is the limit in relation to the other.

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