**Clogging of the Wells by Salts and Corrosion Products**

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**Abstract.** The decline in well productivity occurs due to the clogging of water inflow pathways by complex composite and cement-like structures called colmatants, formed by the combination of salts, corrosion elements from the metal equipment, and the small sand particles carried by water. Additionally, the stable operation of wells is often disrupted by irregular functioning of water-lifting devices (pumps), unexpected power outages, clogging of water pathways in the layers forming the filter and pre-filter zones, resulting in a decrease in filtration coefficient, deterioration of water quality, and localized or widespread drops in water levels. These issues create significant problems in regions that rely on groundwater resources. This article is dedicated to addressing this problem.

**Keywords:** Groundwater, well, productivity, colmatation, filter, solid particles, clay particles, layer, water resources.

**INTRODUCTION**

In the context of the Republic of Uzbekistan, the uneven distribution and limited availability of water resources have led to severe shortages of potable water resources. The state of groundwater is influenced by climatic factors such as air temperature, atmospheric precipitation, and the duration of high-temperature periods, which cause glacier melting and rising river water levels. These changes affect the operation of water abstraction wells and the overall performance of water supply systems. In Uzbekistan, 81–83% of water supply systems rely on groundwater resources. Currently, more than 48,000 artesian wells are in use across the country, and 10–12% of them are not operating at their designed efficiency levels annually. Introducing advanced technologies to enhance the efficiency of artesian wells, which serve as water extraction facilities from underground sources, is undoubtedly essential.

**METHODS**

In scientific studies, the colmatant, which significantly impacts well efficiency, is recognized as having a complex composition and unique structural properties. For research purposes, we classify it as solid particles. The movement of such particles is subject to certain limits, gradually creating problematic conditions. Suspensions of solid particles pass through the pores into the filter, a process that leads to the formation of colmatation around artesian wells.

The hydrostatic pressure of a well at a specific depth exceeds the pressure of the fluid filling the drilled layer. As a result, water begins to filter through the well. This process causes clay particles to settle and form a clay layer within the well. A similar phenomenon occurs during cementation, which leads to the closure of existing openings in the well.

The resulting filter and clay layers are porous and permeable. However, their porosity and permeability generally depend on the pressure drop across the layer, as these layers are usually compressible. If the size of the particles is smaller than the average pore thickness of the surface where the filter is applied, some of these particles penetrate the internal environment.

Mathematically, the sedimentation process of these particles can be described as follows: The total volume VJ  of a homogeneous mixture (suspension) is equal to the sum of the volumes of the liquid and solid particles, Vt​. Thus, the fraction of the layer occupied by solid particles can be expressed by the following equation: (1).

Due to filtration and sedimentation of particles, Vt decreases over time by the amount of dt and dVt, let's assume that the composition of the mixture (suspension) VJ does not change dVJ, then the value of Ft remains constant, that is, we get the following expression.

During filtration, solid particles accumulate in the pores of the filter or on its outer surface in the form of a shell. We denote the area elements in which the deposition of solid particles occurs by δA and by dXK, and we determine the increase in the thickness of the layer of these particles over time by dT. If the particles are deposited inside the filter, they can occupy only a part m of the layer δAdXK, where m is the porosity of the filter medium. In this part of the layer, they form a pore (structure), the porosity of which is denoted by μk. The resulting particles are all equal to the following, i.e.

The fluid flows through the area δA in a certain time dt. Denoting the normal component of the fluid flow over the area δA by Vn, we obtain the following expression:

The expression is given a minus sign because the fluid estimated from the area δA is assumed to be directed towards the outside. From equations (3), (4) and (2), we obtain an equation for the growth rate of the shell thickness.

This is different from equation (5) in the corresponding equation in (2).

For a filter layer deposited on the outer surface of the filter, we obtain the same equation, where we must set m=1.

Multipliers

They are called internal and external coefficients, respectively. Since the shell is always weakly compressed, the porosity of the shell changes with decreasing pressure, therefore the coefficients of subsidence are not constant values, if subsidence occurs at a constant pressure drop, then the coefficients ωB and ωH can be considered constant.

The settling of solid particles and the flow of liquids obey Darcy's law. In the outer shell, the permeability layer is Kk, and in the case of internal sedimentation, the permeability is less than the value. It can be approximately taken as mKk. The compressibility of the layer, the permeability Kk. In the case of internal sedimentation, the permeability is less than this value.

It can be taken approximately equal to mKk. The compressibility of the Earth's crust also depends on the pressure drop due to its permeability Kk.

**RESULTS AND DISCUSSION**

To show how the above quantities can be measured and to reveal the microscopic properties of the described filtration process, we will consider a straight-line flow.

A suspension (mixture) is poured into a vertical cylindrical vessel with a permeable porous bottom (1). Let us assume that only external sedimentation occurs, in which case the filter and the filtered layer are not compressed. We write Darcy's law for this case.

Where a is the bottom area p and m are the density and viscosity of the filter q is the estimated flow rate along the positive x axis of the filter The fluid moves downward, i.e. flows, as shown in Figure 1. An equation of the same form (with K instead of Kk) occurs at the bottom of the pore.



**FIGURE 1.** Scheme for studying the formation of the soil crust

1–air, 2–suspension (mixture), 3–filtration layer, 4–pore bottom, 5–filtrate

Since the fluid is considered incompressible, the continuity equation takes the form formula (9)

So everywhere

∂ρ∂x

The boundary conditions for the situation are written as follows:

*p=ax+b* for - *XK<x<0*

*=x+* for 0*<x<L* (11)

Here Pv is the air pressure above the suspension, h is the height of the layer column above the shell surface, and PC is the suspension density.

Using these boundary conditions, we can determine the constants a, b, a1 and b1. As a result, we obtain the following expression, i.e.

Here, using (12), we find the following.

From this equation and equation (5), taking into account that the beginning of the shell is at the point x=-xk, we obtain the following expression:

h and fT result in

Given the volume of liquid filtered over time T, the initial value of hH, and the fact that Q=0 at t=0, integrating equation (5), we find the following.

We substitute Q from (17) into equation (15) and the resulting expression h into equation (14). Then we integrate equation (14) with the condition that Pb= const.

In this calculation, we usually calculate Pb as pressure. It is very good compared to pressure due to its own weight. We can determine that for large values ​​of Pb, and the equation is approximately correct.

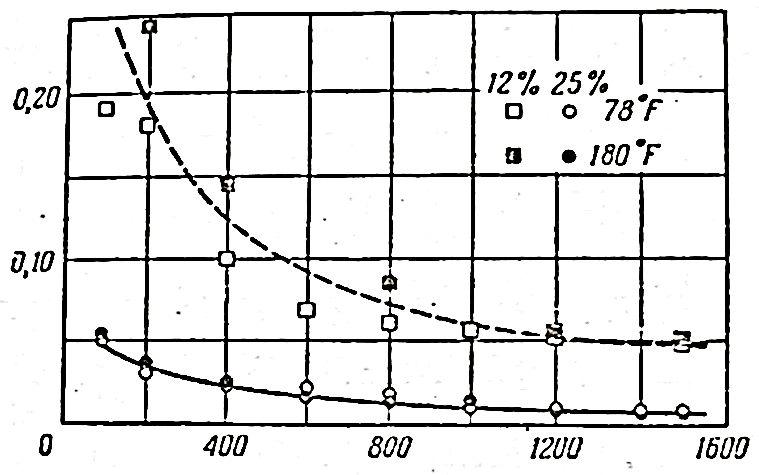
We obtain this equation at the time t=0 by integrating Xk=0.

Given the values ​​of Q and Xk, we can simultaneously find t and then use equation (17) to find an expression for WH.

This value can be used to calculate Kk, knowing the values ​​of L, Pb, K, M, Xk, and T, using equation (19).

From this formula

Note that the value of Q includes not only the volume of filtrate flowing through the bottom of the pore, but also the volume of filtrate that saturates the bottom. It is possible to saturate the bottom with filtrate before starting the process.



**FIGURE 2.** Permeability of the filter layer as a function of pressure drop for various bentonite cement slags (Binkley et al. 1958)

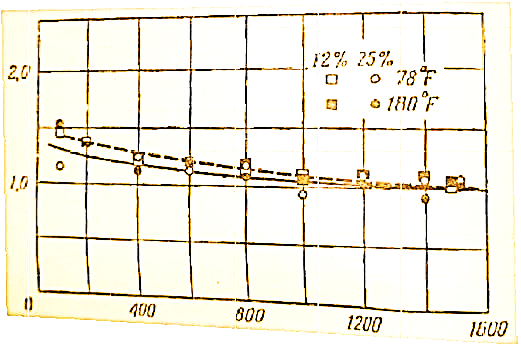
Along the axis of the abscess: pressure drop (pounds/gram m2=0.0703kg/cm2)

On the ordinate axis: permeability of the filtered layer, k (md)

For small values ​​of L, both values ​​Xk and Q increase proportionally (correspondingly) Nt. The dependence of these quantities on time is often repeated in the literature for large values ​​of time. Some of the results obtained using the described method are shown in Figures 2–3. These figures show graphs of the dependence of the values ​​of Kk and Wn, and Wn is the pressure difference for two cement suspensions (mixtures). One of the suspensions consists of water and 12% bentonite clay. The second contains 25% bentonite clay (clay). It can be seen from the graphs that, although the permeability of Kk varies significantly with changing pressure drop, the coefficient ωH remains almost constant.

In the analysis and solution of sedimentation problems, the boundary condition between the filter layer and the suspension has the following form:

Here ds/dt is the velocity of the hill boundary in the direction perpendicular to the boundary, and V is the volume flow.



**FIGURE 3.** Dependence of the external coefficient of bentonite clay (sludge) cement suspensions (mixtures) of different compositions (Binkley et al. 1958).

On the abscissa axis: pressure drop (pounds/gram2) On the ordinate axis: sedimentation coefficient Wn. Filter along the boundary, N is the unit vector in the outer transverse direction of the boundary. Therefore, it is possible to advance the boundary of the filter layer shell of any shape.

**CONCLUSION**

1. The mathematical expressions for the settling of solid particles above represent the settling of the colmatant formed in the fluid as it moves around the well;

2. If the fluid movement in long-running wells and the parameters of its movement medium (density, porosity, velocity) are known, it is possible to determine the changes in the filtration medium around the well due to the sedimentation of solid particles;

3.If the level of clogging due to the deposition of solid particles in the pre-filter and filter areas of the well is determined, then it becomes possible to determine the change in flow rate and decrease in efficiency;

4.The importance of these theoretical conclusions makes it possible to construct a mathematical module for declogging technologies, which is the reverse process of solid particle deposition;

5.This, in turn, accelerates the removal of settled solids and makes it possible to use various chemical compounds in the treatment of wells.

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