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INJECTION PROPAGATION MODEL IN SANDY SOIL

This articles focuses on the process of injection solution in the sand as physical phenomena. During theoretical studies of the propagation of the fluid phase in a porous medium, actual is the definition of the parameters of the jet, necessary for layer material discontinuity in the contact zone of the jet to the surface. It can be achieved through the injection process modeling in a dispersion medium by constructing geometrical similarity of injection jet. It is found that the propagation of the fluid phase in the solid body pores suggests that as they reach the point at the distance from the injector to the «end» of the jet in pores pre-saturated by water, gradual change in injection rate depending on the initial rate of efflux and viscosity occurs..

***Keywords:** soil injection, dispersion medium, physical modeling, solution jet, dispersion medium.*

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МОДЕЛЬ ПОШИРЕННЯ ІН'ЄКЦІЙНОГО РОЗЧИНУ В ПІЩАНИХ ҐРУНТАХ

Розглянуто процеси ін'єкції розчину в пісок з позиції фізичних явищ. Зясовано, що в теоретичних дослідженнях процесу поширення рідкої фази в пористому середовищі актуальним є визначення параметрів струменя, необхідних для порушення цілісності шару матеріалу в зоні контакту струменя з поверхнею. Виявлено, що цього можна досягти за допомогою моделювання процесу ін'єкції в дисперсне середовище шляхом побудови геометричної подоби струменя ін'єкції. Установлено, що розподіл рідкої фази в порах твердого тіла передбачає, що в міру досягнення крайньої точки відстані від ін'єктора до «кінця» струменя в попередньо насичених водою порах відбувається поетапна зміна швидкості розповсюдження ін'єкційного розчину залежно від його початкової швидкості витікання та в'язкості.

***Ключові слова**: ін'єкція ґрунтів, дисперсне середовище, фізичне моделювання, струмінь розчину, дисперсійне середовище.*

Introduction. During the study of the interaction of the dispersion medium with the dispersed phase it is rational to create a model on the level of structural inhomogeneities. It was considered that in a moving jet of dispersion medium, which is a multi-phase non-Newtonian fluid, soil particles can not accumulate or transfer mechanical energy from the rotor flux [1].

Analysis of recent research and publications of sources. In hydro or aeromechanical interaction the kinetic energy of the selected soil particles can be transformed into potential, although the effectiveness of such an accumulation of potential energy is much smaller than in the case of motion of Newtonian fluids in disperse systems [2 – 4]. For a qualitative description of such processes one of the effective ways at an early stage of their research is their modeling [5 – 6]. Physical modeling of injection into the soil it is the fundamental definition of their parameters under the model characteristics found in its study [7 – 8]. A feature of the physical modeling is that the characterizing does not require mathematical description of the processes, but an idea about the mechanism (physical nature) of the phenomena, in order to properly calculate the parameters of the main subject according to tests of its model. Since the physical modeling of the physical nature of the phenomena that occur in natural product and the model is the same, according to the results of experiments on the models, the nature and effects of the quantitative relationship between the values for field conditions can be evaluated [9].

Isolation of previously unsolved aspects of the problem. The task of theoretical studies of the fluid phase propagation in the porous medium includes determining of a minimum dynamic pressure of the jet necessary to discontinuities in the material layer of the jet in the contact zone with the surface.

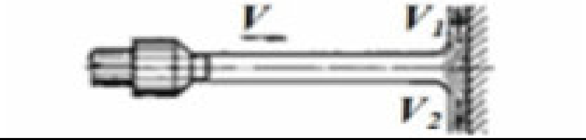
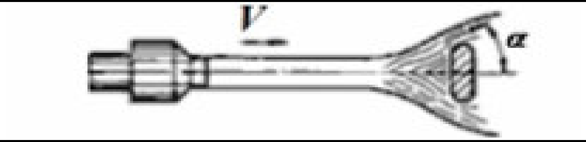
Formulation of the problem. To determine the fluid jet parameters required for dynamic fracture of the layer of porous material, it is necessary to study the interaction of the jet with the surface of the solid phase particles. In order to assess this interaction it is necessary to know the characteristics of spreading of free axially symmetric jets.

Main material and results. The model of the propagation of the jet injection in the soil was taken as an analysis object. Under the injection jet it is considered the jet that goes from the injector into the thickness of the material, with a shape that is characterized by a length L and propagation diameter D_0. The model of conical jet allows to analyze the mechanisms of its propagation depending on the pressure. The form of propagating jet in the form of a cone assumes that, depending on the width of its propagation, in its volume, the fluid phase is in the free state, in the form of polyabsorption layers and a monoabsorption layer in close proximity to the apex of the cone. At the fluid discharge from the injector in heterogeneous environment, by virtue of obstacles (Table 1) [10], there is a pressure on certain areas. Based on this assumption, we conditionally allocated four zones that characterize the gradual spread of the fluid phase to a solid medium at ρ = const, Fig.1.

Depending on the accepted model of fluid phase injection into the solid, one or another mechanism of interaction is proposed. When presentation of soil as a capillary-porous systems the main focuse is made on processes and phenomena that occur in the pores and cavities of various sizes in the propagation of fluid in them.

The main factors influencing the spread of fluid in the system include: discharge pressure effect on the modeling material particles; a hydraulic pressure of the fluid and its migration to the weak places; capillary effects associated with changes in pressure, depending on the concentration of the fluid; osmotic phenomena associated with the occurrence of concentration gradients of pore fluid; crystallization pressure that occurs during chemical reactions of hydration.

Table 1 – Examples of jet interaction with the stationary surfaces [10]

Interacton scheme	Pressure by interaction
	$P=\frac{\gamma}{g}QV$
	$P=\frac{\gamma}{g}QV(1-cos\,a)$
	$P=\frac{\gamma}{g}QV(1-cos\,a)$

where V – exhaust velocity of jet compressed section; Q – flow of fluid; a – angle of jet deflection; γ – speed factor.

In the event of adoption of a fictitious soil model as a two-component system, consisting of a matrix in which the distributed switching (sand), the main attention is devoted to the differences in the absolute values of grain parting coefficients of matrix and impurities of the material.

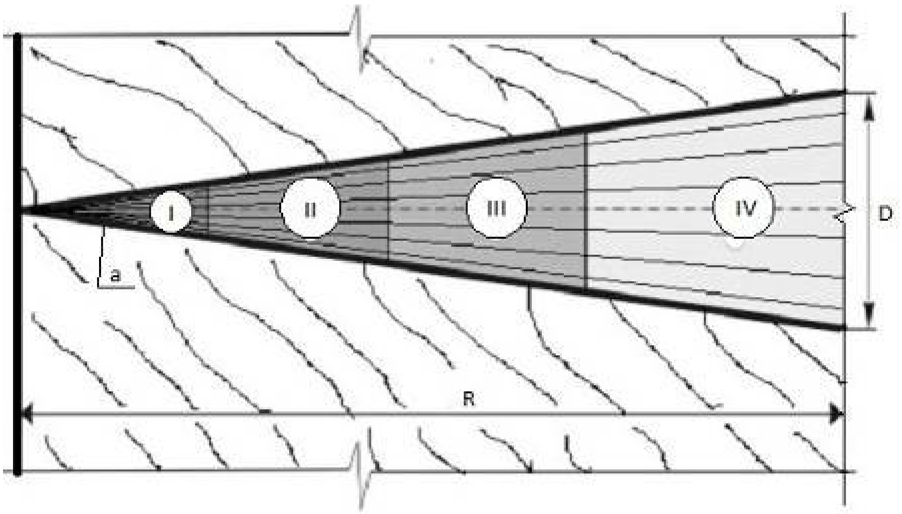


Figure 1 – Model of conical jet into a dispersion medium in the context:
R – the length of the jet; *(D)* – the diameter of the jet propagation; a – propagation angle;
I, II, III, IV – zone, characterizing gradual propagation of the fluid phase in a solid medium

Analysis of the structure of moistened (system moisture is about 5-6% by weight) quartz sand (as a false model) sandy soil showed capillary interaction of small particles of sand large. «Adherent» particles form aggregates-globules, which are in turn building the «arched» structure. This penetration of the fluid under pressure in its pore spaces may lead to a parting of the grains and the violation of their capillary interaction.

Due to the fact that the adhesion strength between particles varies due to the difference in their size, it is logical to assume that the first fluid jet will increasingly lead to a breakdown in communication and greater parting directly at the head of the injector, i.e. where the speed of the outflow is maximum. It may be due to the fact that the adhesion strength of the particles is much lower than jet response force.

For structures composed of discrete units, interacting through the internal interface, the diffusion mass transfer coefficients may vary by orders of magnitude. Therefore, in such cases, it is appropriate to speak not about the local («crevice») mechanism of mass transfer, but the front as wide enough area formed under the effect of gradients jet velocity. Such assumptions allow to extend the idea of distributing a fluid phase jet at different pressures in the discharge of its bulk of the solid. Due to the fact that first of all at samples injecting into thickness the solid particles come into operation, producing surface effects, when selecting the model we will assume that the jet extends deep into the compressed material in the form of a cone. Model of false soil with a single jet in the form of a cone, the base of which is ellipse, shown in Fig. 2a.

In general terms cone surface of the second order is based on ellipse; in a suitable Cartesian system of reference *(x-axis* and *y-axes* is parallel to ellipse axis, the top of the cone coincides with the origin, center of the ellipse lies on the axis *Oz)* its volume equation has the form:

$$V_{cm} = \frac{1}{3}\pi Rr \cdot H = \frac{1}{3}\pi Ox \cdot Oy \cdot Oz = \frac{1}{3}\pi O_1A \cdot O_1C \cdot OO_1 \ .$$

In the most general case, when the cone is supported by an arbitrary flat surface, it can be shown that the equation of the lateral surface of a cone (with the vertex at the origin) is given by the equation, where the function is homogeneous, i.e. satisfying the conditionfor any real number α.

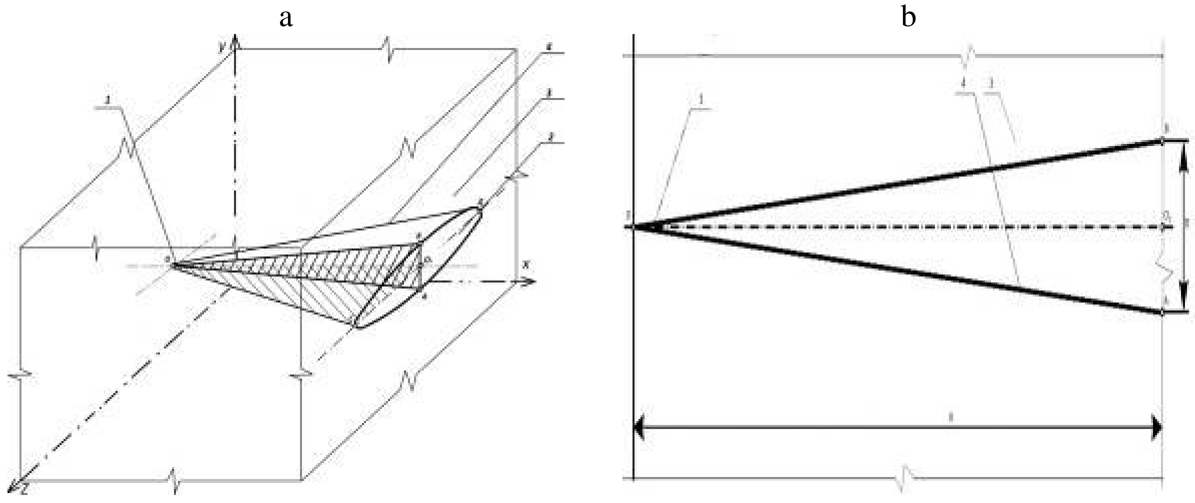


Figure 2 – Model of injection jet propagation in the false soil:
a – cone-shaped jet model; b – jet model fragment in cross section
1 – (pole) the mouth of the jet; 2 – jet dissipation area;
3 – model ground; 4 – external jet bound

As adopted in the terminology and characteristics of the jet in the hydrodynamics it includes present exterior free jet boundaries, which are characterized by their surface area; jet front, defined by its length or length; jet pole, estimated by radius of the pole. At the first stage we will analyze planar (two-dimensional) model of a jet, which is a sectional view of a bulk jet passing through its axis of symmetry (AOB, fig. 2.b). Thus, as the jet model dimensional wedge jet is adopted, which is characterized by the spread diameter (D), a length (R), exterior boundaries (OA, OB) and the radius of the pole, Fig. 2. b.

If assume that the diameter of the jet propagation (D) is influenced by the initial velocity of its outflow. The wedge shape of the jet suggests that along its length the speed of propagation varies. Propagation of the fluid in a solid body over time may not match the rate of movement depending on the structure of the matrix material. It is due to the fact that with increasing of particle size of the solid material as the distance from the injector in the volume of the material the propagation velocity decreases. Moreover, it is interesting to note that such jet propagation is observed in the air as well, Fig. 3 [1]. The adopted jet model and the jet propagation speed change scheme depending on the distance from the pole is shown on Fig. 4.

In general, the following areas for the propagation velocity of the jet can be identified

– OE area, where in the jet has a velocity substantially equal to the nozzle outlet;

– EG area, wherein the jet slows down the speed of propagation due to the frictional forces on the surface of the particles;

– GO_1 portion$_1$ wherein the jet practically lost initial kinetic energy, water is in monoabsorption state.

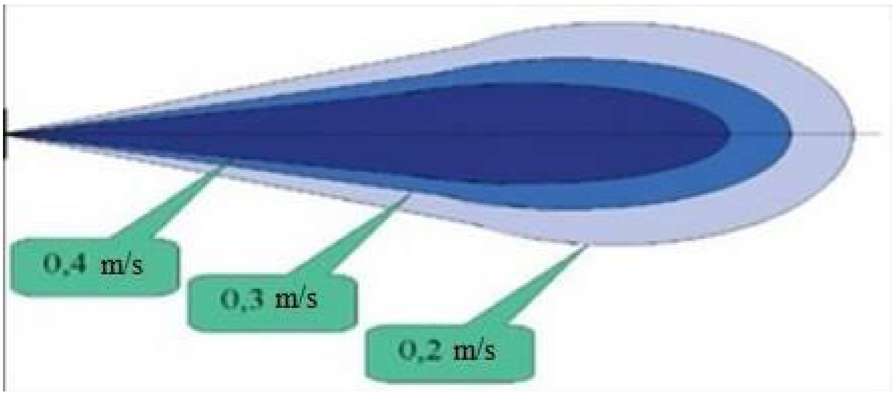


Figure 3 – Model of jet propagation speed in a homogeneous medium

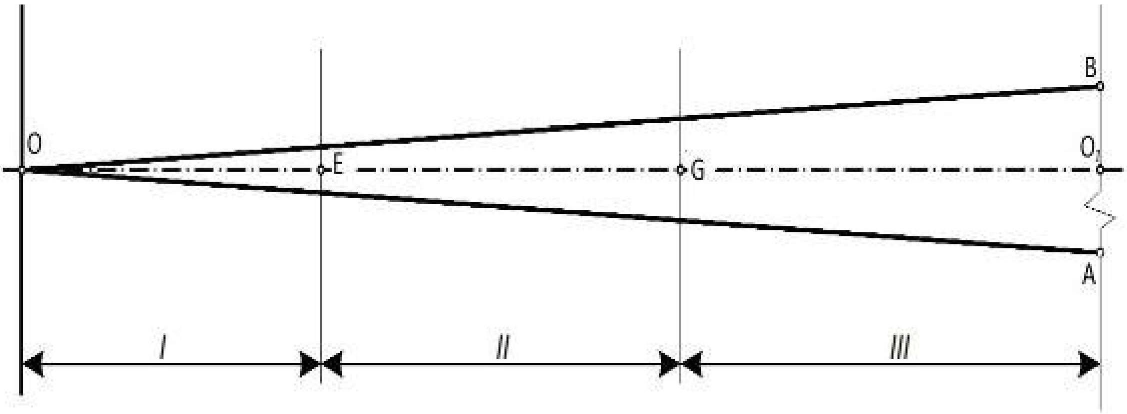


Figure 4 – Propagation of the propagation velocity in the material on the jet length in the jet model:

I – area of propagation without changing the speed of initial outflow of the jet;

II – area of of the jet propagation with the speed slowdown due to the friction forces occurring on the surface of the particles to a greater extent;

III – area of the jet propagation in which it significantly slows its speed, expanding in diameter at the same time

Propagation of the fluid phase in the pores of a solid body suggests that as they reach the point at the distance from the injector to the «end» of the jet in pores pre- saturated by water a gradual change in injection rate occurs depending on the expiration of the initial rate and viscosity.

Conclusions. The research which were carried out allows us to take for analysis the following jet propagation models in the model soil:

1. Model jet propagation in sand, arranged on a principle «fluid in the solid body» includes jet injections at different levels of structural inhomogeneities due to its

propagation. The analysis allowed simulate jet which, depending on the distance from the injector changes the propagation form and speed. Such jets includes jet, the propagation of which took place at a pressure = const.

2. As a jet model a two-dimensional wedge-shaped jet with fixed parameters is adopted. The wedge shape of the jet is taken on the assumption that along its length, due to changes in the distance from the injector, its speed reduces due to increasing friction with the soil particles. Changes of communication between the soil particles occur between the opposite shores. It involves changing of the radius of the propagation by length of the jet.

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