საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 11, №2, 2017
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 11, no. 2, 2017

Hydrology

Dynamic Microwaves in One-Dimensional Dredge Flow at Separable Phase Flow

Otar Natishvili

Academy Member, Georgian National Academy of Sciences, Tbilisi, Georgia

ABSTRACT. Adaptation of the model of separable motion of dredge carrying (water, solid particle) flow at hydraulic calculation of irrigation collectors with periodical purification allows us to predict the occurrence of microwaves in two-phase flow due to the change of the solid component only along the way in the limits of construction. *© 2017 Bull. Georg. Natl. Acad. Sci.*

Key words: stability of the flow, dredge flow, solid phase

Theory of homogeneous flow considers the simplest method of investigation of one or polyphase flows. The corresponding average properties are defined and mixture is considered as quasi continuum described by equations of one-phase medium. To analyze homogeneous flow the average parameters are necessary: velocity, density, viscosity and others. These properties seem to be average weighted.

Insufficiency of the theory of homogeneous approach in some cases is quite evident, especially, while considering the variants of two - phase (dredge carrying) flows in collectors with periodic purification.

In the model of separable flow the phases can have different properties and velocities. This model can be investigated by methods of different level of complexity. The most detailed analysis is based on the equations of continuity, motion and energy separately for each phase. Those six equations are solved together with the equations describing character of interrelation between the phases and walls of the collector. In the simplest case the disagreement for collectors is allowed only by one of the phase parameters: velocity parameter. Equations of conservation are described for mixture as a whole. When a number of variables subjected to definition exceeds the existing quantity of equations, the correlation dependences are introduced or simplified assumptions are allowed. Other variants are also possible.

In the given case to save the most general form of the used equations is advisable, which will serve as the basis for generalized solution of the task.

Dynamic waves of two phases (dredge carrying) flows are formed every time when the resulting force acting on the flow is condition by the gradient of concentration (in the given case composition of dredge in the mixture of two phase flow.)

Consider stationary motion of dredge flow in straight prismatic bed of constant cross section with genuine velocities of phase V_1 (water) and V_2 (dredge).

To make the dynamic microwave unmovable we render the velocity „V_w “ to the whole system of mixture. In a new system of phases flow there will be:

$$V_1^1 = V_1 - V_w \quad (1)$$

$$V_2^1 = V_2 - V_w \quad (2)$$

The equations of continuity will have the form:

$$\frac{d}{dx}\left[V_1^1(1-S)\right] = 0 \quad (3)$$

$$\frac{d}{dx}\left[V_2^1 S\right] = 0 \quad (4)$$

The equations of motion will be [1]:

$$\circ_1 V_1^1 \frac{dV_1^1}{dx} + \frac{dP}{dx} = K_1 \quad (5)$$

$$\circ_2 V_2^1 \frac{dV_2^1}{dx} + \frac{d\circ}{dx} = K_2\,, \quad (6)$$

where: $\circ_1$ and $\circ_2$ are densities of water and dredge; P - average pressure in live cross section; K_1 and K_2 - the total of mass and surface forces, acting on the unit of volume of each component; S - volume concentration of dredge (i.e. volume share of the component 2).

Composed forces of K_1 and K_2 are: effects of the mass change along the way at separable relative motion of phases, Interaction among the particles of dredge, impulse change and other forces of resistance. Taking away (6) from (5) we get:

$$\circ_1 V_1^1 \frac{dV_1^1}{dx} - \circ_2 V_2^1 \frac{dV_2^1}{dx} = K_1 - K_2 \quad (7)$$

Dynamically microwaves will exist in two phase flow in the case, when right part of (7) will linearly depend on the gradient of dredge concentration in the mixture:

$$K_1 - K_2 = -f_S \frac{dS}{dx}\,. \quad (8)$$

Inserting equation (8) into (7) and excluding $\frac{dV_1^1}{dx}$ and $\frac{dV_2^1}{dx}$ with the help of (3) and (4), we get:

$$\frac{\circ_1\left(V_1^1\right)^2}{1-S} + \frac{\circ_2\left(V_2^1\right)^2}{S} + f_S = 0 \quad (9)$$

Expressing $\left(V_1^1\right)$ and $\left(V_2^1\right)$ via initial velocities (1) and (2), we get square equation relatively „V_W “:

$$V_W^2\left(\frac{\circ_1}{1-S} + \frac{\circ_2}{S}\right) - 2V_W\left(\frac{\circ_1 V_1}{1-S} + \frac{\circ_2 V_2}{S}\right) +$$

$$\frac{\circ_1 V_1^2}{1-S} + \frac{\circ_2 V_2^2}{S} + f_S = 0 \quad (10)$$

Hence:

$$V_W = \left[\frac{V_1 \circ_1}{1-S} + \frac{V_2 \circ_2}{S} \pm \sqrt{\frac{-\circ_1 \circ_2 \left(V_1 - V_2\right)^2}{S(1-S)} - \left(\frac{\circ_1}{1-S} + \frac{\circ_2}{S}\right) f_S}\right] :$$

$$:\left(\circ_1/(1-S) + \circ_2 S\right) \quad (11)$$

Introducing the average dredge velocity:

$$V_0 = \frac{\dfrac{V_1 \circ_1}{1-S} + \dfrac{V_2 \circ_2}{S}}{\circ_1/(1-S) + \circ_2/S} \quad (12)$$

and velocity of dynamic microwave in the form:

$$C = \pm\sqrt{\frac{\dfrac{-\left(V_1 - V_2\right)^2}{S/\circ_2 + \dfrac{1-S}{\circ_1}} - f_S}{\circ_1/(1-S) + \circ_2/S}}\,. \quad (13)$$

Then equation (11) will take well-known form of wave motion [2]:

$$V_W = V_0 \pm C \quad (14)$$

Thus, dynamic microwave V_W move relatively to average nonweighted velocity V_0 with velocity $\pm C$, determined by equation (13). As $V_1 > V_2$, the value of f_S must be quite big in order to press perturbing motion of the relative motion.

ჰიდროლოგია

ორფაზიან ნაკადებში მიკროტალღების წარმოქმნის პროგნოზი ცალკეული ფაზის განცალკევებულად გადაადგილების პირობებში

ო. ნათიშვილი

აკადემიის წევრი, საქართველოს მეცნიერებათა ეროვნული აკადემია, თბილისი, საქართველო

ჰომოგენური მოდელი ფაზათა (მყარი, თხიერი) განცალკევებით გადაადგილების დროს, რასაც ადგილი აქვს პერიოდული მოქმედების საირიგაციო დანიშნულების სალექრებში, არ იძლევა საშუალებას დადგინდეს მიკროტალღების წარმოქმნის შესაძლებლობა მითითებულ ნაგებობებში.

ნაშრომში შემოთავაზებული მიკროტალღების წარმოქმნის პროგნოზი ემყარება ორფაზიანი ნაკადის ცალკეული ფაზის მასით განცალკევებულად გადაადგილების პირობას, რის გათვალისწინებაც აუცილებელია სალექარის გეომეტრიული პარამეტრების დასადგენად.

REFERENCES

1. Natishvili O.G., Tevzadze V.E. (2012) Odnomernye nanonesuschie ruslovye potoki. M. 192 (in Russian).
2. Natishvili O.G. (2016) K voprosu o skorosti dlinnykh nepreryvnykh voln v sklonovykh stokakh. *Meteorologia i Gidrologia,* 1: 99-102 (in Russian).

Received March, 2017