CENTRAL ASIAN JOURNAL OF MATHEMATICAL THEORY AND COMPUTER SCIENCES
https://cajmtcs.centralasianstudies.org

Volume: 03 Issue: 12 | Dec 2022 ISSN: 2660-5309

SIMULATION OF FLOW AERATION IN A CLOSED SECTION WATER LINE

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Abstract

In this article, we present the most optimal methods for determining the critical speed corresponding to the beginning of aeration, from the results of several analyzes of the analysis of the results of the calculation of the critical speeds, from the empirical connections to the prediction and assessment of the phenomenon of aeration of the flow.

ARTICLEINFO

Article history:
Received 18 Oct 2022
Revised form 19 Nov 2022
Accepted 21 Dec 2022

Keywords: *aeratsii, zakhvatyvaemogo pryjkom, poverkhnosti vozdukha, gidrodinamicheskogo podobiya, chislo Fruda, chislo Reynolds, chislo Weber.*

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INTRODUCTION. According to its structure, the aerated flow is not homogeneous. In the two-layer model of motion, the most well-known and accepted in the normative [2, 7] and reference literature, the flow consists of a lower water-air region, the water mass of which contains air trapped on the surface, and an upper air-droplet region, the air of which contains water in droplets ejected upwards.

A large number of factors and forces (forces of gravity, resistance, surface tension) that determine the self-aeration of the flow do not allow ensuring the equality of the hydrodynamic similarity criteria (Froude, Reynolds, Weber numbers) when modeling the process of aeration initiation and air capture by the flow. Therefore, the main method for predicting the phenomenon of flow self-aeration and determining its characteristics should be considered a calculation method based on the use of methods and empirical formulas available in the literature.

$$Q = 1500\,;,2000\,;,2600\,;\frac{м^3}{сек}$$

Expenses showed that their value, calculated according to the formula of N.B. Isachenko [3,4], turned out to be 11 - 16% more in comparison with those calculated by the formula of T.G. Voynich-Syanozhentsky. According to S.M. Slissky [5, 9], the formula, which gives a relative error of about 15%, is more reliable and accurate than the known dependences of N.B. Isachenko, G.P. Skrebkov and V.S. Sinelshchikova, A.A. Nichiporovich, V.E. Rusakova, O.M. Morina, L.G. Gogiberidze, De Lapp, Doma, Ehrenberg, Powell, Okada and others. At present, there are still no sufficiently reliable methods for calculating flow aeration.

Aeration in a conduit of a closed cross section is possible with free flow, if the Froude number reaches a certain critical value.

A large number of works have been devoted to the issue of determining by calculation the flow of air captured by the flow in water conduits of a closed section. There are relevant field observations carried out at hydroelectric facilities in the USA, Japan, Norway, Italy, India, Russia [6-8]

With free water surface without a hydraulic jump and a Froude number less than the critical one (at the beginning of aeration), air is drawn into the conduit only due to friction at the water-air interface and flow aeration does not occur. The flow rate of air captured by the sprayed jet when flowing from under the shutter at small openings (Fig. 2, a) can be in fractions of the water flow rate - obtained by the formula [1, 5]

MATERIALS AND METHODS

The graph takes into account the influence - the ratio of the flow area in the compressed section to the area of the conduit. In addition, for the considered case of motion, we obtained.

$$\beta = 0{,}09\sqrt{Fr_1}$$

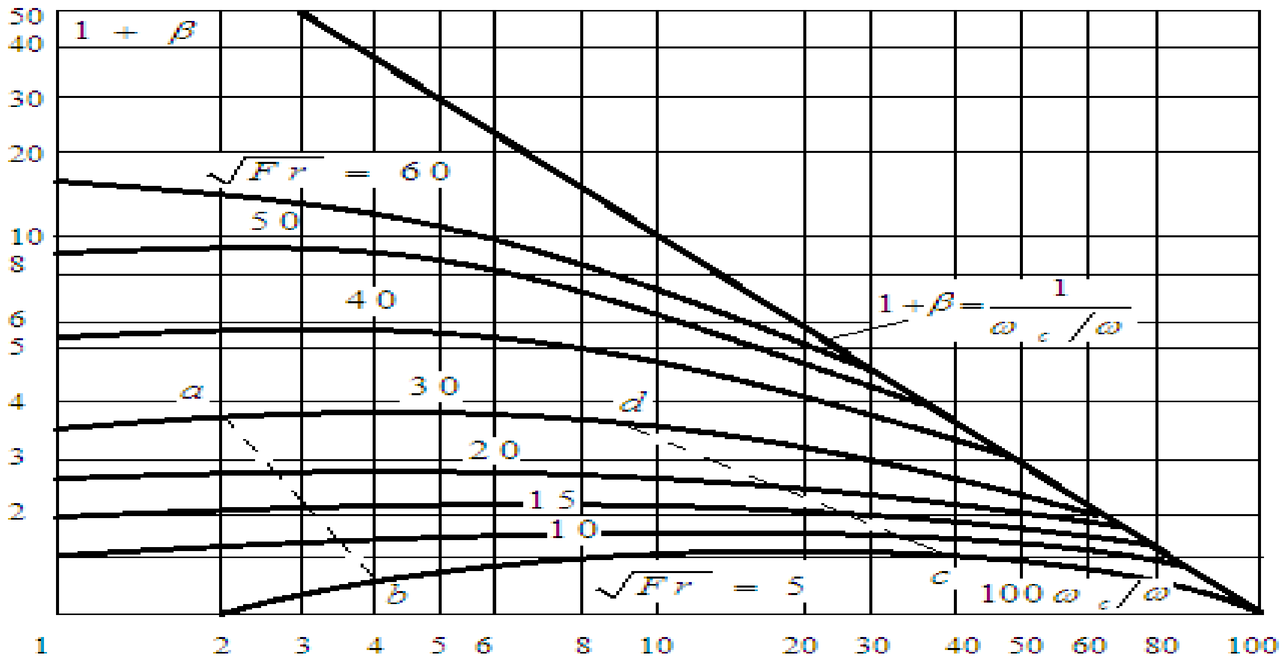

Fig.1. Graph for determining the flow rate of air entering the water conduit of a closed section with a turbulent free-flowing flow in the water conduit.

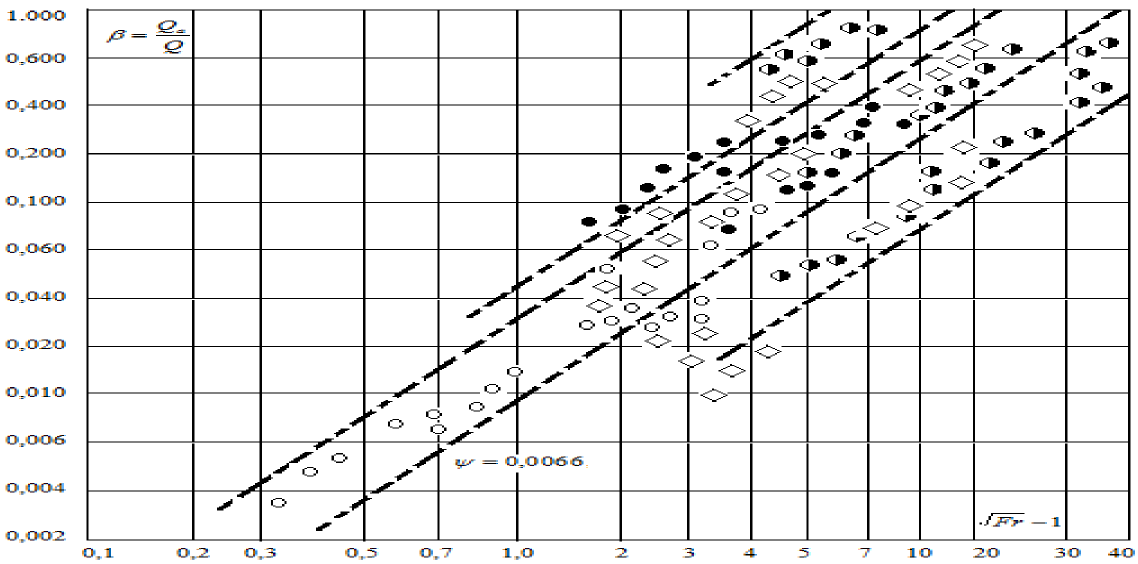

Fig.2.Experimental data on the capture of air by a hydraulic jump in a conduit of a closed section. Laboratory and full-scale according to [2];-laboratory data [4]; - laboratory data according to [2, 3].

RESULTS:

Here the Froude number is calculated for the compressed section behind the gate. With the transition after a jump to a pressureless mode, the air flow through the conduit increases sharply. In Fig.6. it is shown how, as the shutter closes during the transition from pressure flow (curve 4) to free flow (curve 5), the air flow rate, having reached 30 m3/s, increased abruptly to 95 m3/s [1,7,10].

Figure.. Shows graphs constructed according to (2), (4) and (5). The number - is calculated here by the depth and speed in the section before the hydraulic jump.

At a given value, the highest flow rate of air entering through the air duct into the water conduit of a closed section was obtained with free flow in the tunnel without the formation of a jump. Approximately the same air consumption is obtained when air is captured by a repelled jump with simultaneous aeration of the flow in the area of repulsed jump, the sum of the values is determined by (3) and (5)].

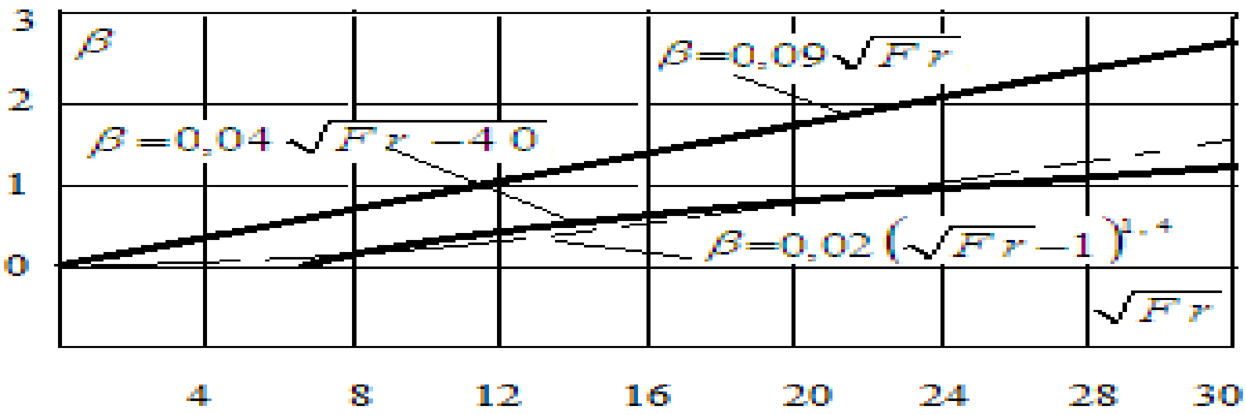

Fig.4. Graphs that determine the flow rate of air entering the conduit under various flow regimes.

Conclusion. In conclusion, it should be noted that there are a large number of works devoted to the study of air entrainment by a flow in a closed water conduit, but the solutions and recommendations proposed in these works give approximate values. Therefore, the process of air capture by the flow in a closed conduit is subject to further study.

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