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ANALYSIS OF A WEDGE-WIRE SCREEN'S WORK

ANALIZA PRACY GŁOWICY SZCZELINOWEJ

A b s t r a c t

The article presents the results of numerical calculations performed in a computer software. The simulations concern water flow through an intake screen. This kind of screen can be used in surface water intakes. Thanks to the small inlet velocities and a small mesh size, the screen does not pose a threat to ichthyofauna.

Keywords: water intake, water intake screen, ichthyofauna

S t r e s z c z e n i e

W artykule zamieszczono wyniki obliczeń numerycznych wykonanych w oprogramowaniu komputerowym. Symulacje dotyczyły przepływu wody przez szczelinową głowice. Tego typu głowica znajduje zastosowanie w ujęciach wody powierzchniowej. Dzięki małym prędkościom wlotowym oraz małym otworom szczelin głowica nie stwarza zagrożenia dla ichtiofauny.

Słowa kluczowe: ujęcie wody, głowica, ichtiofauna

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1. Introduction

Human intervention, including regulation of rivers and streams, construction of water intakes and dams, poses a threat to ichthyofauna. Depending on the type of construction, there are various types of dangers for ichthyofauna. An example of such a threat can be a disruption of river continuum as well as danger for fish and fry connected with getting into hazardous parts of the water intake installation.

As a result of the intensive investigations into the phenomenon of upstream fish migration and fish passage restoration, today, there are defined details on the dimensioning and design of functioning upstream fish passes available. It is undisputed that upstream fish passes contribute substantially to a sustainable protection of the ecosystem [2].

Despite the high awareness of the necessity to ensure migration up the river, the issue of downstream fish migration receives little attention. A major threat to the migrating fish is posed by hydroelectric power plant's water intakes. Nevertheless, water intakes supplying drinking water are also a problem.

The degree of negative impact of water intake on the ichthyofauna depends on the number, size, arrangement of ichthyofauna and swimming ability of individuals, as well as the water velocity, inflow into the intake and depth at which the intake is installed. Other important factors are the type and size of water intake and the mesh size of a screen [1].

In order to protect fish and fry from entrainment, special devices known as physical barriers are installed in water intakes. These are the intakes equipped with special screens. The screens can have different shapes. A cylindrical wedge-wire screen is taken into account in this study. Inside the wedge-wire part of the screen, there is a deflector installed. The aim of the deflector is to equalize the velocity distribution on the surface. It is obtained thanks to different sizes of slots.

2. Wedge-wire screen

One of the materials that the screen can be made of is wedge-wire. It is a commonly used material in modern water intake screens. In this type of screen, the broad side of the bars forms the screen surface that faces the flow, so that the bars become smaller in the flow direction, while the clear spacing widens in the wedge-shape.

This type of screens significantly reduces the risk of injuries to fish as the small clear spacing of the bars and the position of the broad side of the triangular shaped cross-section against the approach flow forms a very smooth surface [2].

Another important aspect is the water intake position in the watercourse. In order to reduce the normal flow velocity, the screens are set at an angle to the watercourse flow. The established flow is parallel to the screen in order to guide fish past the screen. If screens are oriented normally (90 degrees) to the channel flow, the fish tend to hold in front of the screens or are impinged on the screen. In either case, the fish are not directed to the bypass entrance [3].

The flow approaching the fish screens can be characterized in a vector format. The channel velocity Vc can be broken into an approach velocity component Va, which is normal to the screen face, and a sweeping velocity component Vs, which is parallel to the screen face. The component oriented normally to the screen face Va, is the part of the channel velocity that draws fish and debris to the screen surface. The component parallel to the screen face Vs is the part of the channel velocity that directs fish and debris along the screen [3].

Thus, it can be said that approach velocity is a determining parameter in terms of ichthyofauna protection in water intakes. According to [3], when the screen is equipped with a flushing system preventing clogging, the approach velocity measured 76 mm (3 inches) from the screen is lower than 0.12 m/s and is safe for fry and 0.24 m/s for fish.

Apart from the approach velocity, the inlet velocity measured in the screen's slots is an important parameter. According to USA guidelines [3], this velocity should be lower than 0.15 m/s to be safe for ichthyofauna.

3. Method

In order to check the work of the water intake screen and to analyze the velocity distribution, the Solid Works Flow Simulation computer software was used. The software provides computational fluid dynamics (CFD) simulation, which is a simulation technique that mathematically simulates fluid flow and heat transfer.

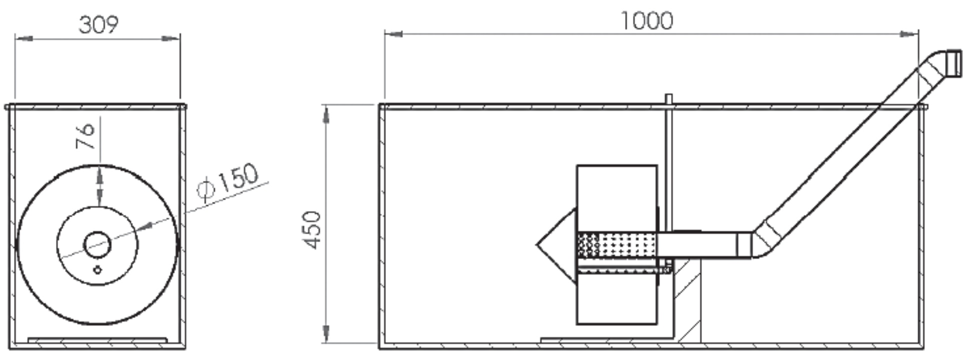

Fig. 1. Dimensions of the model

The dimensions of the analyzed water intake screen are presented in the Fig. 1. The screen's diameter equals to 150 mm. Inside, there is a deflector installed. At 76 mm from the screen, the velocity measurements were performed. It was assumed that the screen is installed in a tank under atmospheric pressure of 101325 Pa. The outflow from the screen equals to 5 kg/s ≈ 432 m^3/d.

4. Results

Thanks to the performed simulations, the velocity distribution during water flow through the screen was found and it is presented in Fig. 2.

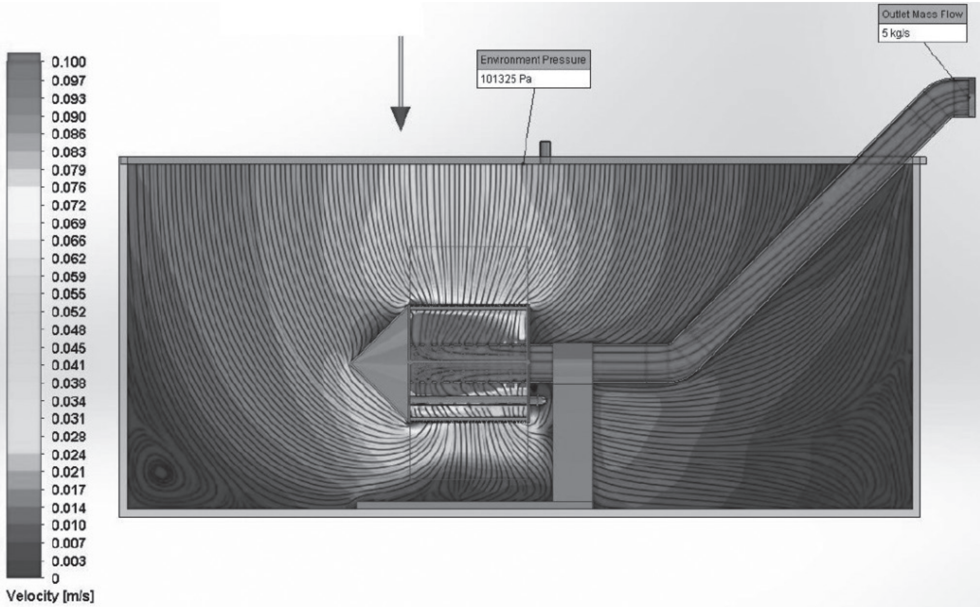

Fig. 2. Velocity distribution

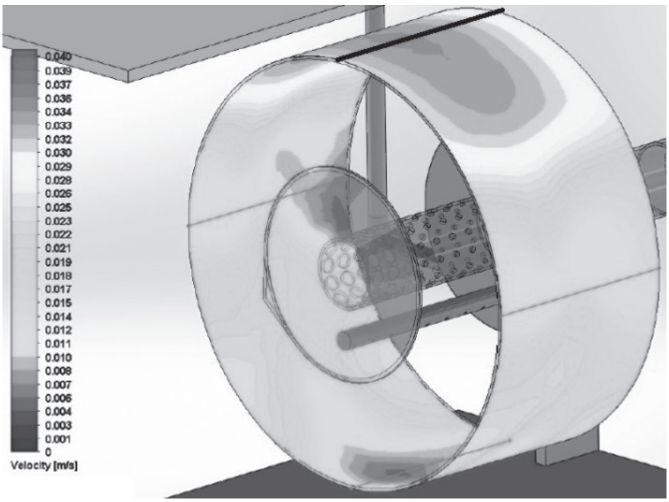

Fig. 3. Velocity distribution within 76 mm (3 inches) from the surface of the intake screen

As mentioned before, the key parameter in terms of ichthyofauna protection is the velocity within 76 mm (3 inches) from the surface of the intake screen. This velocity distribution is shown in the Fig. 3.

It can be seen that the maximum values of velocity appear above the water intake screen surface. A more precise distribution of velocities within 76 mm from the upper surface (along line marked in the Fig. 3) is shown in the diagram in the Fig. 4.

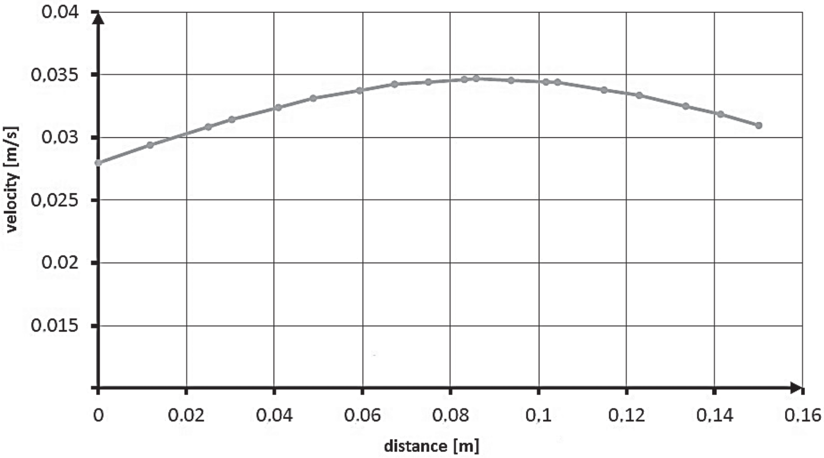

Fig. 4. The velocity distribution within 76 mm (3 inches) from the upper surface of the intake screen

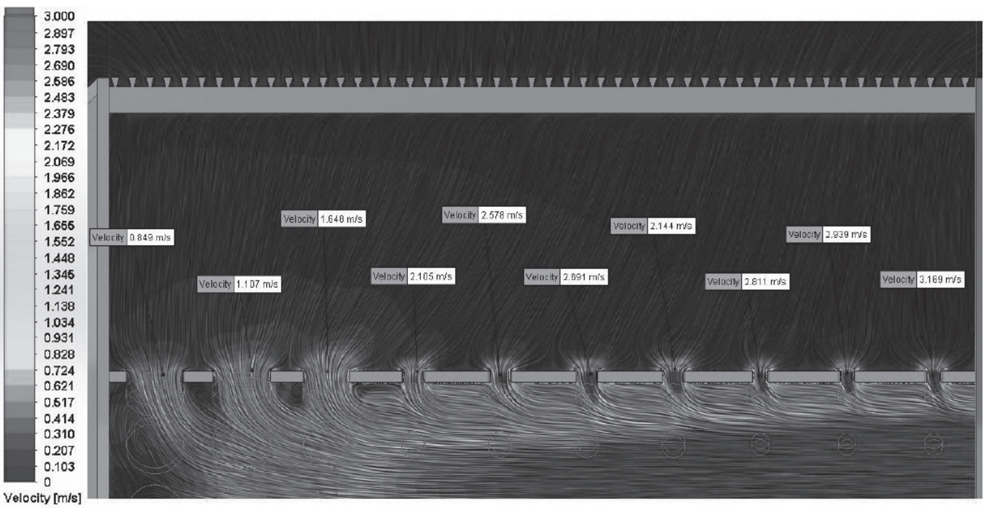

Fig. 5. The velocity distribution in the deflector’s slots

According to Fig. 2 and Fig. 3, it can be said that the velocity within 76 mm from the surface of the screens, at each point, is lower than 0.035 m/s. The crucial velocity value that may pose a threat to fry is 0.12 m/s. Thus, it can be concluded that the analyzed water intake screen should not threaten ichthyofauna. What is more, such a small difference in velocities is favorable for a water intake screen. A huge difference could lead to uneven work as well as clogging of some parts of the screen.

A steady velocity distribution on the screen's surface is obtained thanks to the use of the deflector. The velocity distribution inside the deflector's different sized slots is presented in Fig. 5.

5. Summary

The used computer software seems to be a good tool for analyzing the cylindrical wedge-wire screen's work. Numerical simulations allow to obtain qualitative and quantitative results of the examined issues. Thanks to the performed simulation, it was possible to determine the velocity distribution inside the water intake screen and around it. It is an essential issue in designing water intake screens protecting fish and fry.

The analyzed wedge-wire screen seems to be safe in terms of ichthyofauna protection. Thanks to a steady velocity distribution on the surface, exploitation problems can be minimized.

References

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