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WATER INTAKE STRUCTURES ON SMALL HYDROPOWER PLANTS

Abstract: Planned model research of river bank water intake structure in the laboratory of Department of Hydraulic EngineeringSTU.
Keywords: Small hydropower plant, water intake structure, hydropower potential.

I. INTRODUCTION

Currently in the world and also in Slovakia we can see growing pressures reversing our attention to the greater use of clean and inexhaustible energy resources. Important place among users of these energy sources are hydropower plants. Period of construction of large dams, which substantially alter the character of the country and significantly affect the environment, is already almost over. Occurs time when it is necessary to pay attention to opportunities the construction of small hydropower plants. According to data from the Research Institute of Energy from 31.12.2001 was registered in Slovakia 186 small hydropower plants with installed capacity of 57.33 MW, which represents 16.86% of total primary technically exploitable hydropower potential (THEP) in MVE.

SHPP have the following advantages:
- is a permanent source of energy, practically inexhaustible,
- a clean energy source that does not pollute its surroundings and is waste-free,
- it's own power supply is not dependent on foreign partners,
- require relatively low investment costs compared with other sources,
- require very low operating costs,
- have a low failure rate, long life and high number of annual operating hours,
- very small number of operational staff
- generate new opportunities for recreation, leisure and sports.

Their renewed development should encourage us to examine the construction solutions of SHPP that will work efficiently and reliably throughout the life.

An important part of any SHPP is also an water intake structure. Nevertheless, they paid insufficient attention. This is evidenced by the whole council of operational difficulties or failure of objects already constructed and the overall stagnation in their design and research.

The greatest deficiencies in the design of intake structures arise when schematic download already completed structures. At one flow may one type of intake structure have very good results, but at another flow, even if partly similar, the same type may show poor results. Operational issues adversely affecting mainly small hydropower plants with a low output level and even becoming a limiting factor for their further development.

II. REQUIREMENTS FOR WATER INLET

On the intake structures has been put board of various requirements affecting the design and structural arrangement of the intake own objects, as well as their parts and components. The most critical requirements include:
- the need to ensure that during all operating conditions and throughout the life of the building taking the quantity of water with minimal handling, energy and complex automation features.
- the requirement that with water intake could not be pulled into sediments and contaminants that could jeopardize the operation of turbines,
- ability to prevent entrainment of air into the intake,
- ability to prevent gullet jam and destroy intake screenings at the time of floods and ice-hazards in time during operation leaves.
- ability to resist dangerous icing or wrap of all exposed and racing elements (screenings, groove closures, aeration pipes ,...)

These requirements are often contradictory, optimally design solution of intake structure can be a compromise of those requirements. The right hydrotechnical proposition of intake structures, respecting all the complex of issues is very difficult because it is specific at each case.

III. THE CURRENT STATE OF DESIGNING SCREENINGS

We always have several options for construction of intake structure screenings of SHPP. The criteria for choosing the appropriate structures are usually the quantity and flow characteristics of drifting sediment and suspended matter, weather conditions, demands for self-service, design requirements and economic costs.

Cleaning and maintenance of traditional fine screenings can’t pass without strenuous and hygienically delicate handwork. Cleaning coarse screening device is secured very little and also requires strenuous, risky and hygiene defective labor. By some SHPP soot coarse screenings at a critical period causes loss of gradient up to 0.5 m.

Often is not fully resolved the liquidation of objects that are trapeed at screenings. In some cases, trapeed materials are letting out back into the water below the water structure and thus largely denies the validity of lifting of trapeed materials of water.

Cleaning of classic belt fine screenings is not only challenging for the scope of service, but also the energy.

Classic fine screenings of strip steel are often shown as little appropriate in light of the used material. In winter adversely applied good thermal conductivity of steel, leading to icing screenings. Due to the aggressiveness of water adversely operates a relatively small resistance of metallic materials against corrosion screenings, which sometimes requires refinishing screenings. Grossly unfair is poor resistance of classic fine screenings to dynamic stresses that can cause the tendency to resonant vibrations. Adverse is also considerable

weight of structure that induces the increased demands for lifting and transport mechanisms. Protocols of guarantee measurements of streams and heads at low-pressure SHPP and HPP suggest that hydraulic loss of clean fine screenings are an average of 0.15 to 0.20 m of useful gradients. If we consider normal operating fine soot screenings, the loss of gradients can be doubled up. To the blockage of fine screenings leads also their shape unsuitability.

All of these operational problems affect mainly SHPP with a small output level and even they are becoming a limiting factor for their further development - especially in relation to problem of loading automation, unattended operation and increasing the overall efficiency of these buildings.

IV. OPTIONS OF IMPROVING THE FEATURES OF SCREENINGS FOR SHPP

A possible way of developing screenings can be seen in the shape and material changes, in the design of screenings and retaining elements and the conceptual changes in the arrangement of the inlet and the entire hydraulic systems of HPP.

Regarding non-traditional materials, for fine screenings for SHPP can be recommended the fiberglass rod. From the benefits it provides, may be mentioned good resistance to dynamic stresses in the aquatic environment. Positive is also low value of modulus of elasticity, ensuring relatively low frequency oscillations in the flow. Another advantage is great resistance to corrosion even in highly aggressive environments, without the need for special surface treatment. Usually in this case suffice just primer paint of fiberglass rods as it ensures the manufacturer. Indisputable advantage of fiberglass rods is their low frost susceptibility. Beneficial are also insulating and antimagnetic properties. Affordability of fiberglass rods in comparison with steel belts is given by limited labour content in production, reducing the number of technological operations, saving electricity in the production, better use of structural material with low weight, leading to savings on lift and transport mechanisms.

Using fiberglass allows relatively easy to modify the cross-section shape. Since the current round profile to perfectly hydraulically displacing profile, whose production requires only the creation of a special form of calibration and for the manufacturer it is technically quite manageable. From appropriate hydraulically changes in the shape of cross-section of rods can be expected reducing of hydraulic losses in comparison with traditional metal bands from 30 to 70%.

In the search for new conceptual patterns of screenings is also needed to answer the question whether it is effective and acceptable that each water intake object was equipped with device for mechanical cleaning of the intake (for lifting and disposal of suspended solids). Considering that the inherent operation of intake and screenings does not require removing suspended solids from water, and that is contrary effectively released them further downstream, as is the case with other hydro-technical constructions, the answer to this question is clearly negative.

In order to make SHPP more effective is desirable to relieve their inlet and screenings from inefficient mechanical cleaning. At each flow would be by the challenge of the mechanical cleaning of water (capture, extraction and disposal of suspended solids) entrusted only selected hydrotechnics construction, which should be for this purpose technically equipped. In other buildings, including SHPP, would then be able to design just wipe of screenings and allow letting of floating objects down to the stream.

However, for secure easy skimming of screenings we should change the orientation of fine screenings from vertical to horizontal position. In order to make operation and maintenance of the screenings more effectively it is necessary to examine the possibility of hydrodynamic phenomena occurring in the operation of SHPP. There can be used for example the oscillation of screenings. Another possible energy source could be the energy of hydrodynamic phenomena, which manifest themselves in the screenings at the sudden shutdown of turbines of SHPP. Following the abrupt conclusion of the turbine flow mainly in low-pressure water plants with short feeder absorbs a significant amount of mechanical energy of water. With proper arrangement of the intake and screening after each shut down of turbines in the screenings generally releases as much energy, which greatly exceeds the total energy requirements for screenings wiped away and washing away suspended solids. Energy source that can also be used for this purpose can be also own hydraulic resistance resulting in progressive choking of screenings.

V. WATER INTAKE STRUCTURES PLACED ON THE STREAM BANK

In the laboratory of Department of Hydraulic Engineering STU in the autumn of this year will be realize research on physical models of bank intake structure of SHPP. It will be devoted to optimal design of various parts of the intake structure and also intake structure as a whole. More attention will be given to proposal of coarse screening device.

Similar intake construction is built on SHPP Roveň. This will serve as a model by physical model construction and on the intake structure can be made in-situ measurements for different values of the flow, and then compared with those values measured in physical model.

This SHPP is located in the village Oravský Biely Potok. It is a derivative SHPP using the flow from Cold Creek. Untraditionality of this SHPP lies in technical solutions of coarse screening device in the water intake, which is operated without much difficulty and maintenance.

The proposal of intake structure significantly reflect the claims of conservationists. These can be summarized approximately as follows:

1. there should be proposed intake structure, which does not require damming the flow and creating a threshold
2. ensure that abstraction of flow does not induce sinking of flow in the river below Q270d (biological flow)
3. minimize the interferences to the environment.

Classical technical solution of intake structure would be in this case building of the bottom intake structure. However, it excludes the condition. 1, because in this type of intake structure is needed to built a threshold across the flow.

By ensuring the biological flow under the intake structure without possibility of controlling the flow we must consider the question of economy of SHPP. Indeed, during the passage of larger flows, they will continue to flow unregulated down the stream without use in the SHPP.

What is involved to minimize environmental impacts, intake structure has been designed relatively of small size and its height fits into the surrounding terrain.

With regard to the requirements of the project was designed lateral diversion structure (on the right side). For similar types of intake structures is necessary to ensure their self-cleaning ability. By bottom intake structures, this ability is more or less secure, but by the side

intake structures it depends on the construction of coarse screenings. In cases where the classical solution (vertically rod screenings) was used, we can often see obstruction which is reflected in rapid rise of loss of hydraulic inlet and thus the decrease in the amount of energy produced.

In our case, the designer came up with innovative solution of coarse screenings and instead of classic rod screenings placed in one plane he proposed the use of strip steel rods, each of which is rotated to the coarse screenings plane by 45 ° angle (Figure. 1).

This rotation provides a reliable self-cleaning ability when the objects brought by the flow have minimal chance telescope between screenings, and just smoothly slip and sail away. By this not very hydraulic molding of screenings are creating losses of useful gradients (about 10 to 15 cm), but similar and possibly even greater losses would be incurred by using conventional design of coarse screenings wchich will be obstructed by floated objects.

This unconventional design of the coarse screenings will be subjected to research in situ, as well in research on the physical model and the results will be generalized for wider use.

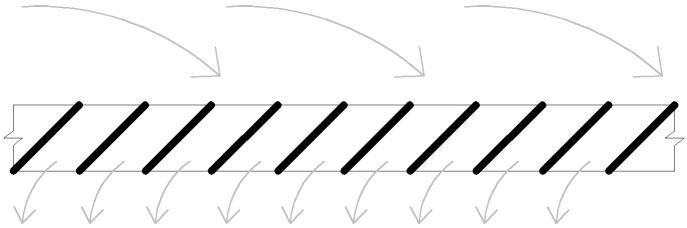

Figure 1. Horizontal cut across coarse screenings of water intake of MVE Roveň

VI. CONCLUSION

Designing of water intake objects of SHPP still has many shortcomings, which translate into functional, self-service and hence the efficiency of operation MVE.

Research on the physical model and in situ should contribute in this issue, and in the design of coarse screenings on SHPP on the upper and middle sections of streams, which are not allowed to damming the flow and use of the bottom intake structure. Results will be interpreted so that they can be routinely used in the design of small hydropower plants in other locations.

ACKNOWLEDGMENT

This contribution is an outcome of a project entitled

"National Centre for Research and Application of Renewable Energy Sources"
ITMS 26240120016

as part of the Operational Programme Research & Development funded by the ERDF

Operačný program VÝSKUM a VÝVOJ

Agentúra Ministerstva školstva, vedy, výskumu a športu SR pre štrukturálne fondy EÚ

Podporujeme výskumné aktivity na Slovensku/
Projekt je spolufinancovaný zo zdrojov EÚ

Európska únia
Európsky fond regionálneho rozvoja

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