Design and construction of a novel low head hydropower convertor at River Iskar, Bulgaria

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Significant unused potential in rivers for small hydro with very low heads (i.e. between 0.5 m and 2.5 m) is still available worldwide and particularly in Europe. Moreover, preliminary investigations in some European countries show that this low head hydropower potential is remarkably high. It is known that the existing water turbine types are not enough economically efficient within this head range. Hence, due feasibility and environmental reasons, innovative solutions for water power use of such low head sites are needed.

A new type of hydropower converters for very low head range is currently being developed within the European Research Project HYLOW in the 7th FW Program of the EC. One of the new types of converters within the research project is Hydrostatic Pressure Machine (HPM). It employs the hydrostatic pressure differences between up - and downstream reaches of the machine. A large scale model (LSM) of the Hydrostatic Pressure Machine (HPM) was built to test the newly developed technology and to determine the efficiency during operation in natural environment at full prototype scale. This paper presents the milestones in the process of design and construction of the LSM.

1 Introduction

The development of the new type energy convertor – Hydrostatic Pressure Machine (HPM) is a complex set of activities and tests on different scale models within the research project HYLOW. Construction and model test of the LSM of HPM is one stage in this study and allows assessing the new technology in real natural conditions and environment. The design of the LSM of HPM is based on theory and previously performed laboratory tests on idealized model. The HPMs are envisaged to be installed in already existing structures in rivers or channels which are abandoned and are not in operation or at structures used for other purposes (irrigation for example). An appropriate site for HPM installation should meet following requirements - heads between 0.5 m and 2.5 m, and available water discharges of 6-8m^3/s. In the frame of this study, the chosen site for LSM installation is at River Iskar, Bulgaria and offers all necessary conditions. It is a weir formerly constructed for water discharge measurements upstream of the large Iskar reservoir in the frame of another research project.

2 Design and construction of the facilities for HPM installation

2.1 Installation site

The installation site at the River Iskar is located after its conjunction with Palakaria River. It is a sill formerly constructed for another research project, completed several years ago. The site is chosen since it offers acceptable head difference and flow rate, and is easy accessible. The site location and the existing sill are shown below (Fig.1)

Figure 1 Installation site at River Iskar and photographs of the existing sill under different flow conditions.

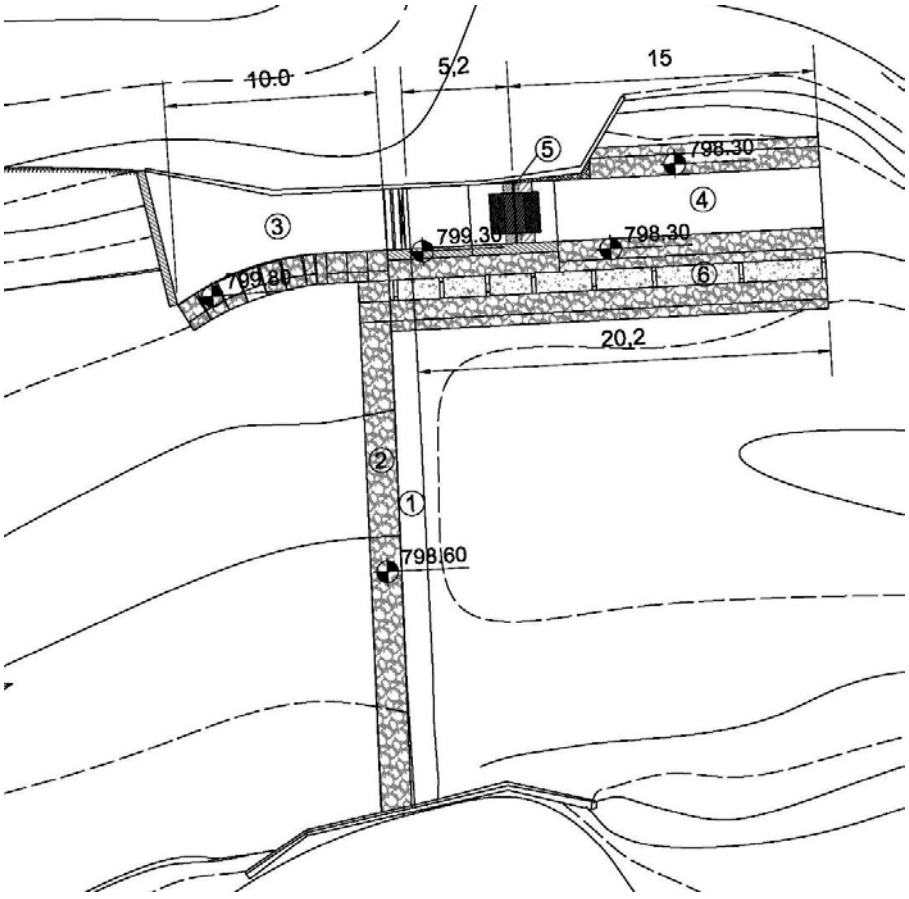
2.2 Reconstruction of the existing facilities

As already mentioned above, the existing structure at the LSM installation site was used for another research project in the past. For that reason, some changes in the shape of the weir and its height became necessary to be performed. The weir was reshaped and slightly heightened in order to meet the new requirements for the LSM installation. For this installation, a new channel was constructed. As the LSM is a temporary structure which should be decommissioned after the end of the project, all construction / reconstruction works have been done mainly using gabions which was considered to be the

most suitable solution in this case. For insuring impermeability of the weir and channel walls, a shotcrete cover was implemented.

For reaching the needed elevation of 798.60 of the weir crest and re-shaping it horizontal, two rows of gabions with dimensions 1.5x1x1m and 1x1x0.5m were placed upstream of the existing weir (Fig.2 and Fig.3).

The channel for HPM installation has been constructed from gabions as well. The length of both inlet and outlet parts of the channel (i.e. the up - and downstream of the machine) is 15,00 m each (Fig.2 and Fig.3). The channel width is variable in the inlet part from 6, 80 m to 3, 00 m. The width of the outlet part of the channel is 3, 00 m.



1 – existing weir; 2 – gabion part of the weir after reconstruction; 3 – inlet part of the channel; 4 – outlet part of the channel; 5- HPM; 6- fish pass

Figure 2 Layout of the LSM installation site at River Iskar.

Figure 3 Installation site view after reconstruction of the existing facilities

3 Large scale model of the hydrostatic pressure machine

3.1 Design of LSM of the hydrostatic pressure machine (HPM)

The design of LSM of the HPM has been performed based on previously conducted laboratory tests by the Technical university of Darmstadt (TUD) and the University of Southampton as well as on the design of a medium-scale model of the HPM to be installed at the channel of a former mill in Partenstein, Germany.

The design discharge for the LSM of the HPM at River Iskar, Bulgaria is 2 m^3/s with head differences of 1,0-1.3 m. The elevation of the hub axis of the installed machine is 798.20. The diameter of wheel of the machine is d = 2,40 m and the width is 2,0 m. The hub of the wheel has diameter of 1,02 m. The number of blades is 10, and they are set at an angle of 15° to the axis of rotation of the wheel (Fig4). The expected maximum power output is 13.7 kW (mech.) for a rotational speed of 16 rpm.

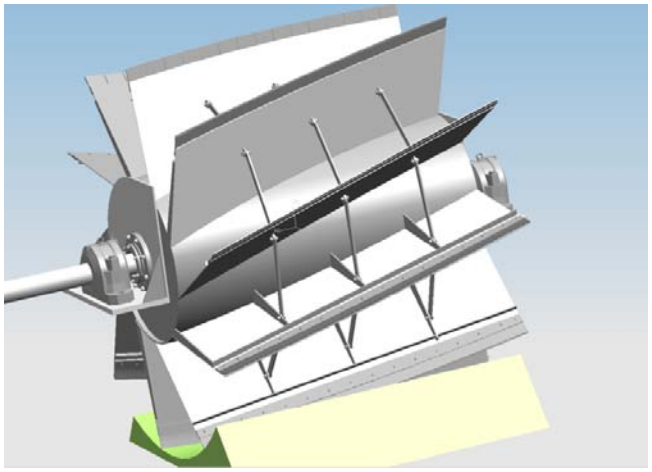


Figure 4 General view of the HPM wheel.

3.2 Construction of a LSM of the hydrostatic pressure machine

The fabrication of a LSM of the HPM has been performed by Energoremont - Plovdiv, Ltd. The main components of HPM are: wheel (D = 2,40 m), axis, bearings, torque sensor, couplings, generator and foundation. During the test operation in the frame of the project, the HPM will be run isolated from the common electrical grid. The produced electricity will be consumed by load resistors and used for charging a battery as well as for supplying the measurement equipment.

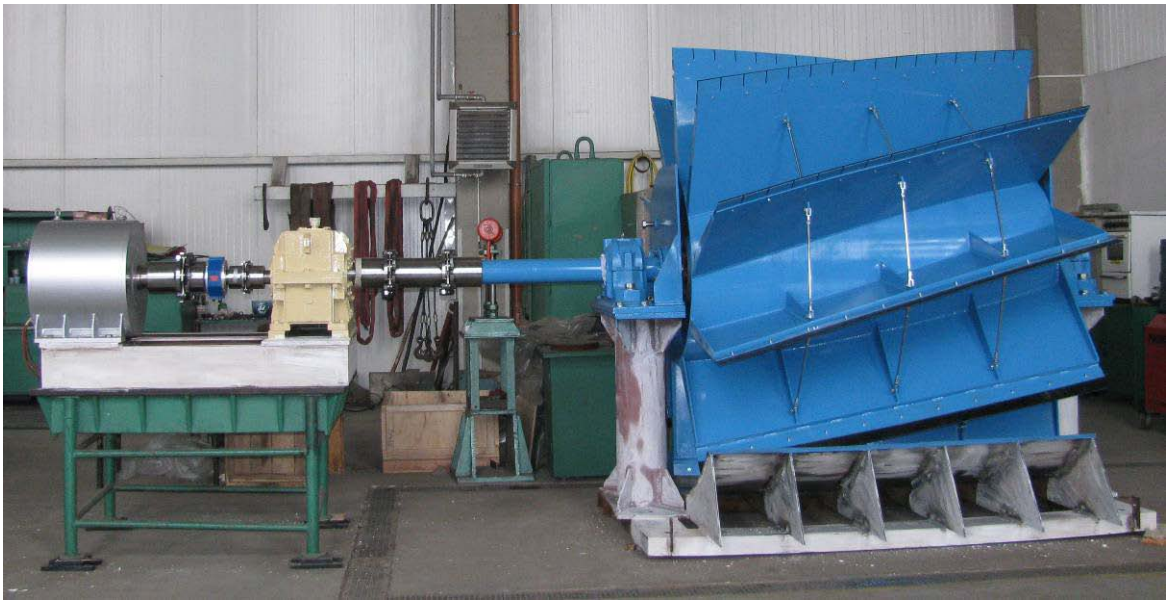


Figure 5 Photograph of the assembled LSM of the HPM at the factory.

Conclusion

The aim of this paper is to present main activities related to LSM installation and HPM operation. Due to unexpected flood event causing some damages at some parts of already constructed facilities, installation of the HPM at River Iskar was postponed. The emphasis of the paper was shifted to the design and construction of the facilities for installation of the LSM of HPM and machine fabrication.

References

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