TO EFFICIENTLY USE
THE POTENTIAL OF BESKO DAM

In the hydrographical network of Podkarpackie region, the lead role is occupied by water catchment areas of the rivers Wisłoka, San and Wisłok (do not confuse with the former). Even though in the context of hydroenergetics, the most recognizable object of this area is the dam on river San in the town of Solina, another damming structure of the region is definitely worth a closer look. The object is Besko Dam on the Wisłok river, and in the near future, another SHP object to dot the map of Poland shall be completed there.

The Wisłok river is the longest of the left-bank tributaries of the San river, measuring a total length of 204,9 km. In its upper course, it flows among densely forested hills of Beskid Niski (Low Beskid) and further on, through Jasielsko-Krośnieńska basin, Strzyżowskie, Dynowskie and Rzeszowskie foothills and via Podkarpacka urstromtal, to find its outlet in the vicinity of the town of Dębno. In the section examined within this article, the Wisłok is a small, flysch river with the average flow of 3.1 m³/s, while at the outlet section the flow increases to 24.5 m³/s.

Fig. 1. A view at the Besko Dam from the tailwater's side.

By the end of the 1970s (1978 to be exact) the Wisłok, similarly to many other rivers in that period, has been barricaded by a massive dam, what has led to the creation of artificial water reservoir, the Sieniawskie Lake, which is also called the Besko Reservoir – named after the town where the reservoir was originally planned to be located (it has finally been placed in the town of Sieniawa). The lake has an area of 1.31 km², minimal depth of 12 m, which reaches 30 meters at its maximum. It is primarily fed by the Wisłok river, but it is an outlet for two other streams – Odrzechowski and Głęboki. Primary functions of the Besko Reservoir (a.k.a.: Sieniawskie Lake) are – water retention and flood prevention in the Wisłok valley below the damming. The reservoir's existence allows for flow equalisation in the river that is characterised by a quick run-off – what causes flood waves to appear on the river several times a year. The water collected in the lake is used to supply drinking water to the population of such towns as Krosno, Sieniawa, Rymanów, Iwonicz-Zdrój and Brzozowo – it is also used to feed a fishing farm, and finally, the potential energy of the dammed waters is used to generate electricity.

THE OBJECT TO BE ADOPTED FOR THE PURPOSES OF ELECTRICITY GENERATION

The dam is situated at 172+800 km of the Wisłok river, its height is 38 m (the dam's crest is located at 338 meters ASL), it has a length of 174 m and there were 70 thousand cubic meters of concrete expended on its construction. The object is made with 14 independent dilated concrete sections that are sealed at dilations with PVC tape. Sections number 7 and 8 are longer than the remaining ones (they are 15 m long, the rest are 12 m) and serve overflow protection and drainage functions.

The Besko Dam is equipped with two bottom drains with hydraulically operated bolts with maximum water expenditure of 2×55 m³/s (110 m³/s in total). Inside the object there are two drainage control galleries that allow for functioning of control and measuring devices at the object. There are 2 pipelines with a diameter of 200 mm each that are destined for biological water flow, which ensure the biological flow to go into the lower sections of the Wisłok below the damming. These pipelines give us the opportunity to use the water that runs through them to generate energy. The original concept of building a SHP in the Besko Dam was conceived in the year 2003. Over the years the concept had been developed while waiting for stabilisation of the hydropower market conditions, so it can finally be completed and commissioned by the end of 2021. Curiously enough, the plant that is currently under construction is not the only object that draws from the energy generation potential of the dam. Since 1992 there is a SHP on the piping that is feeding raw water to the Sieniawa Water Purification Plant. The third object of this kind exists at the feed pipeline to the trout cultivation facility located 500 m below the body of the dam on the river's left bank.

SHP'S ARRANGEMENT AND EQUIPMENT

The construction project for the new powerplant assumes ensuring flow over the turbine through the biological flow pipelines that connect to each other in the drainage chamber to form a common piping serving as a turbine inlet. The hydroset shall have an installed power of 0,075 MW (75 kW) and will operate continuously over the head heights of 19 to 25 meters and flow rate of 0,3 m³/s. It shall be set-up in a layout with a horizontal shaft, the runner of the turbine will be placed in a helical feed inlet – the turbine shall have an external flow control actuation system and will be connected to an asynchronous generator. Everything shall be terminated with an outlet pipeline, allowing for the release of water back into the Wisłok just below the damming, within the stilling basin and sustaining the biological flow in the river. The SHP shall be connected to the existing electricity infrastructure, but it will be equipped with modern control system. The implementation of

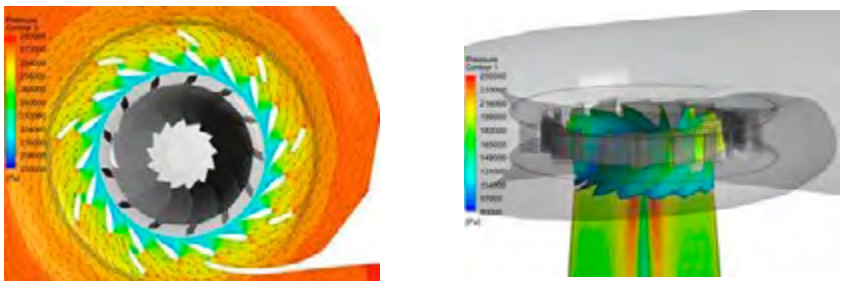
this project in the abovementioned form, apart from needing a professionally-made, detailed design documentation that could ensure efficient turbine operation, lack of pressure losses, elimination of the probability of cavitation – allowing for high hydraulic efficiency of the entire installation, and the best possible placement of all the components to allow for lengthy and reliable operation, also required a plethora of indirect actions. For that matter it is necessary to obtain: an environmental permit based on the technical concept, a decision on land development and management conditions as well as water permit and grid connection conditions. Even though SHP is being completely built within the premises of the existing infrastructure of Besko Dam, the investment's legal and formal preparatory works required obtaining a full set of the abovementioned administrative decisions.

MODERN AND HIGHLY EFFICIENT HYDROSET

Regarding the construction solutions within SHP Besko, there will be one turbine that will be fed through a steel helical inflow chamber. Straight suction pipe shall be attached using flange to the existing pipeline, and the turbine shall be connected to a generator via a transmissionless coupling. The entire hydraulic system has been individually designed and optimised to suit this particular use-case by R&D department of IOZE hydro. The first step to do it was to draw a two-dimensional design of a Francis turbine to serve as a base for creating its 3D model. Then the 3D model has been optimised using CFD simulation to enhance efficiency and decrease the chance for cavitation. ANSYS-CFX highly-specialised software has been used to perform the simulation. Owing to the individual design approach, a dedicated solution has been created – the one that fits perfectly with the local hydrological conditions. The efficiency of the turbine's hydraulic system has been designed to be around 94% under the optimal running conditions.

Transposition of these values from the digital world into the real one was done by creating all the key components of the turbine using multiaxial CNC machining devices. The perfect shaping of the designed turbine and its components, and above all the turbine's runner has a substantial impact on ability to reach maximum possible efficiency value while preventing the undesired phenomena, e.g. cavitation. Machining any components of water turbines demands precision and repeatability in creation of their complex geometry.

Fig. 2. Visualisation of a CFD simulation for a Francis turbine.



ADVANCED MANUFACTURING TECHNOLOGIES IN THE HANDS OF THE INVESTMENT'S CONTRACTOR

The runner of the Francis turbine, its guide vanes and cams of their actuators have been made with high-quality stainless steel by machining it on an OKUMA 5-axis multipurpose lathing and milling centre. This kind of a machine ensures an exact representation of a designed shape – its kinematic structure bolsters the device's stability, guaranteeing a desired accuracy and repeatability in detailing. The OKUMA machining centre is equipped with vibration dampening and temperature compensation systems that allow for achieving the desired values of surface roughness. In the context of using advanced technologies, it is worth mentioning that the preparatory works for the investment involved taking an inventory of the object's existing layout and its infrastructure. For this reason a detailed inventory has been created. It served as a basis for the detailed design documentation. As a part of the inventory-making detailed measurements of intake pipelines and outlet connection have been conducted. There was a significant difficulty in measuring the outlet connection and the outlet compensator, as both of these elements are located below the flooring, so it was necessary to use a laser scanning technology by employing a Faro Vantage laser tracker. This solution has been chosen on the grounds of the fact that the SHP equipment shall be embedded within the existing building and its internal layout, but there was no available realisation documentation. The contractor's engineers, using an array of laser tracked points to gather spatial data, have created a mapping of all the relevant spatial components with an accuracy of 0.016 mm/m. Highly sensitive technology has allowed to avoid any unpleasant surprises during the installation works.

COMPACT SOLUTIONS FOR SHPS

SHP Besko is an example of the object where the concept of compact solutions has been implemented. Installation of the key hydroset components, as well as testing it have been conducted at the production facility. Since the project's inception, at its every stage, including production, the goal was to minimise time necessary for installing and launching the electricity generation infrastructure at the installation destination. The devices that leave the production plant are ready-made modules available for quick and efficient installation within the existing construction infrastructure. IOZE hydro is a supplier of modern, efficient and high-quality water turbines.

Apart from traditional solutions, IOZE hydro also supplies compact SHPs to be either frame-mounted or in a form of a containerised unit. The target market of this product primarily lies abroad, where a significant factor that is decisive when it comes to the investment's execution is the scope of construction works required to place a hydroset at the destination. We invite all those who are considering implementing a modern turbine individually tailored to the object's needs, for an individual walkaround in our production facility. We will gladly show what the process of selecting, designing and producing hydrosets looks like at IOZE hydro.

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