FLOW RATE (DISCHARGE) MEASUREMENTS IN HYDROPOWER PLANTS BY MEANS OF GIBSON METHOD

Key words: flow rate measurements, discharge measurements, Gibson method, pressure-time method

Pressure-time or water hammer method, commonly called the Gibson method, is the one of the basic methods for flow rate measurement applied in hydropower plants. It consists in flow rate measurement basing on integration of pressure difference between two pipeline cross-sections during fast flow stopping. Each unit of hydropower plant equipped with penstock of a length exceeding 4*D* (four times of its internal diameter) is suitable for application of the method Gibson. In the toughest conditions, with no access to the pipeline shell from the outside, special manifolds for receiving the pressure in measuring cross-sections can be prepared from the inside of the penstocks, after draining the pipeline.

Pressures or water levels are measured using high precision transducers, class 0.2% or better.

Values of flow rate are calculated from pressure signals by means of the *GIB-ADAM* code, developed by Dr A. Adamkowski, several times validated in laboratory and *in situ* conditions and repeatedly employed in many hydro-sets in Poland and Mexico.

Lately in the Institute of Fluid-Flow Machinery PASci in Gdansk the special method has been developed which is dedicated for cases of more complex hydraulic geometries, e.g. curved penstocks. The analysis of pipeline curvature on flow rate measurement is based on CFD calculations. Grounding on one case it was already demonstrated that the correction determined by this means changes the results of flow rate measurement through the turbine for about 0.4% and the uncertainties of flow measurements are about 1-1.2% depending on measuring conditions.

Furthermore, utilizing the Gibson method to flow rate measurement through water turbines requires the knowledge of leakage rate through closed guide vanes, i.e. through the blade interspace. Know-how about the leakage rates is also needed to estimate energy losses during turbine shut-down, basically in cases when the cut-off valves and sluice valves are leaky. The procedure for estimating their values was worked out.

In years 2003-2010 the Gibson method was successfully applied in energy efficiency research on many hydropower units in Poland: hydropower plants Zarnowiec, Solina, Dychow, Zydowo, Niedzica, Koronowo, Zur, Pilchowice, as well as in Mexico: hydropower plants Angostura, Infiernillo, Chicoasen, Aquamilpa, Malpaso, Temascal, Villita, Villita, Cobano, Novillo, Santa Rosa, Bacurato

Example of water hammer method (Gibson method) application

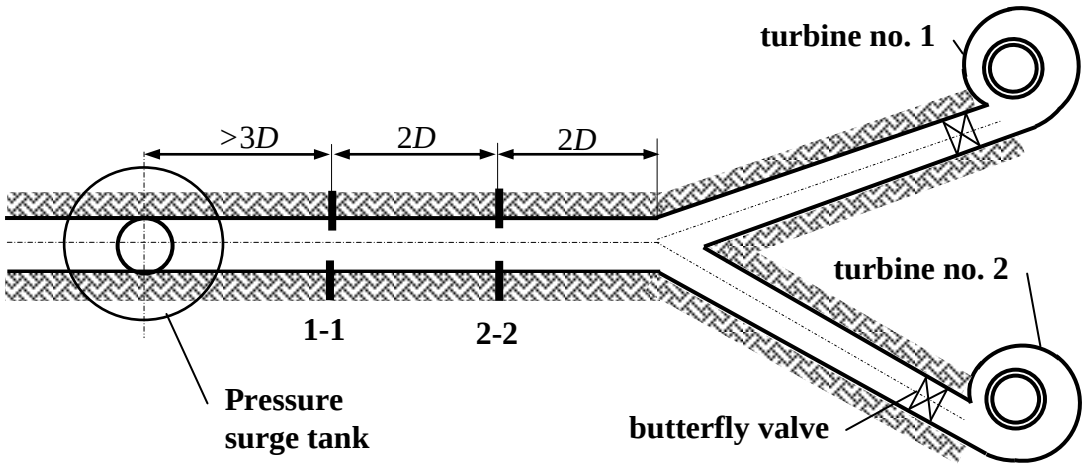

Fig. 1: Schematic diagram of supply system of turbines under investigation with marked hydrometric sections which were used in Gibson method

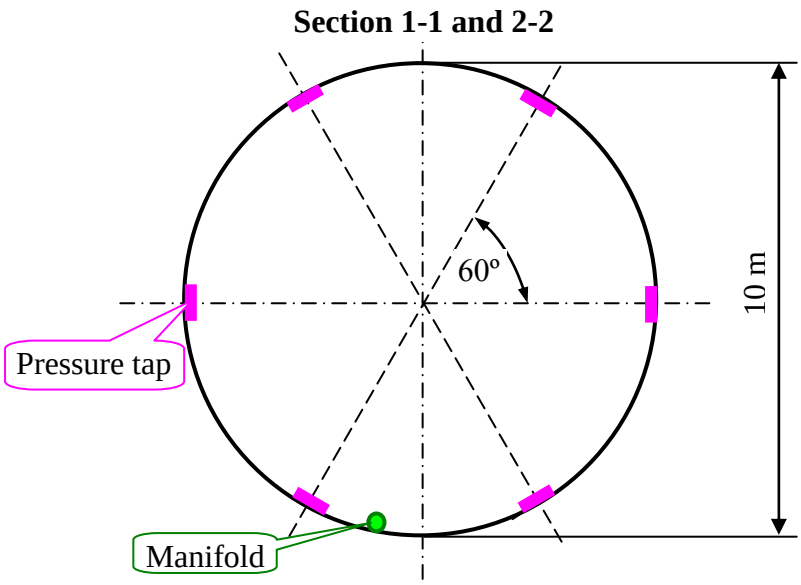

Fig. 2: Localization of pressure taps at each pipeline section 1-1 and 2-2.

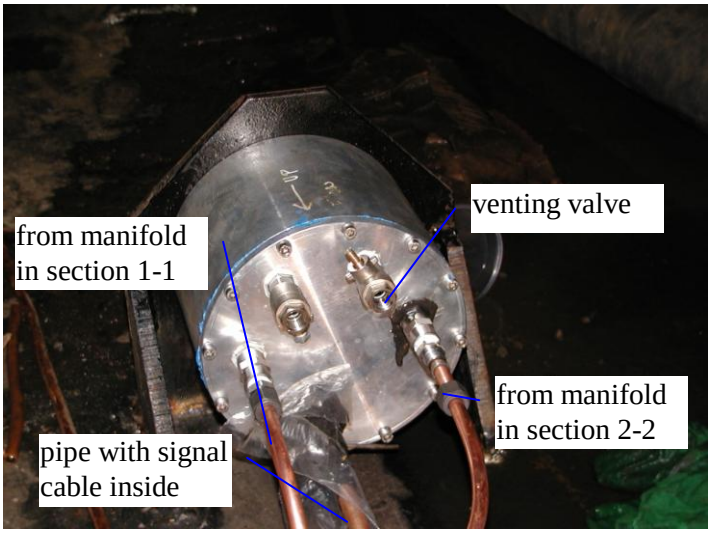

Fig. 3: Waterproof housing with pressure difference transducer installed inside.

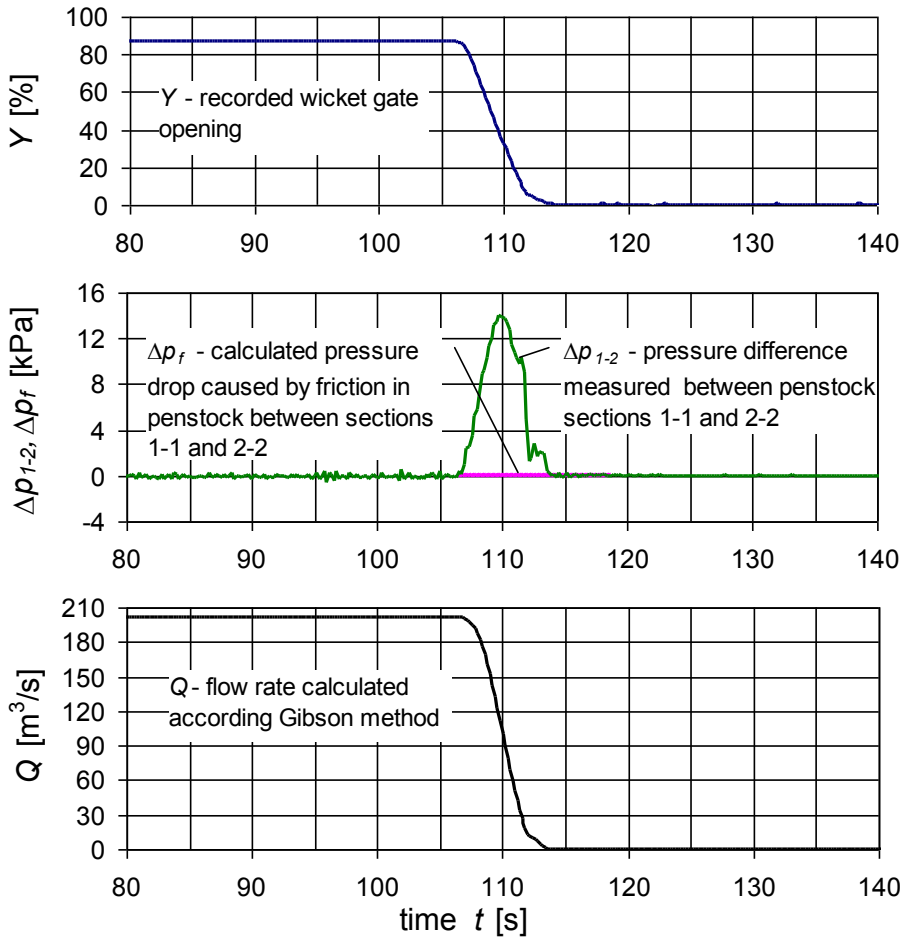

Fig. 4: Recorded and calculated time changes of values related to discharge (flow rate) measurement by means of Gibson method

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