Efficiency Measurement of Hydro Power Stations

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ABSTRACT

Hydropower is currently the most common form of renewable energy and plays an essential part in global power generation. Hydropower provides a significant amount of energy throughout the world and is present in more than 100 countries, contributing approximately 15% of the global electricity production.

Hydraulic turbines are particularity not being individually designed in large quantities and are always unique designs for specific given hydraulic sites. With greater globalization of manufacturing facilities including new locations, extending equipment availability, increased performance and reliability as expected from long running hydro production units, necessitate the increase in monitoring and evaluation of the units. For efficiency measurement of hydro turbine the measurement of discharge is the most important component. In the present time the discharge measurement methods at site have been modernized.

Further the necessity of testing and evaluating the performance of small hydropower (SHP) plants is felt globally due to a variety of concerns (a) subcontractors with no domain expertise are being involved in design, construction or installation of SHP plants, (b) newcomer equipment suppliers without much experience are replacing the established manufacturers, (c) the contractual relationships between the plant owner, designer, contractor and supplier are not very transparent and (d) there are hardly any standards and guide-lines prepared for addressing the issues related to SHP plants specifically.

The Government of India (GoI) Ministry of New and Renewable Energy (MNRE) laid considerable emphasis on the good performance of new SHP stations and to ensure the same it has linked the financial incentive to SHP owner with the performance of the station. This has brought about total transparency in the contracts between the owner, contractor and equipment supplier with a view to ensure a healthy competition based entirely on the quality of services and products.

The focus on the efficiency test on generating units, the most critical and difficult part of the performance testing of a hydroelectric power station is often neglected, as the matter is treated fait accompli. The efficiency testing of irrigation canal fall based hydro power plants is difficult due to large discharge and slow flow velocity. The feasible method for discharge measurement often is mounting the propeller current meters. However, a high uncertainty is often faced in the evaluation of unit efficiency.

The requirements of the efficiency and index tests, alongwith the measuring methods to be used, are wholly covered by the International Electrotechnical Commission (IEC) standard IEC-60041. Another standard IEC-62006, relevant to small hydro turbine, has been also released in 2010 but has several references to IEC-60041.

The unit efficiency test presents a real challenge to the test team. Each site has different parameters and is a different situation, which often requires innovation, improvisation or ingenuity in applying the available methods/instruments for measurements. Required provisions for carrying out measurements normally are not available.

As per IEC-60041 the choice of the method of measurement may be influenced by the factors (a) limitations imposed by the design of the plant, (b) cost of the test equipment and its installation and (c) limitations imposed by the plant operating conditions, for example, draining of the system, constant-load or constant discharge operation, etc.

Use of an array of propeller current meters, although cumbersome, is a time-proven method. The current meters are mounted on a fixed or movable frame to be used in headrace channel, tailrace channel, intake gate opening or draft-tube gate opening. The method becomes extremely time-consuming and difficult when used in closed channels and penstocks. Fabricating and installing temporarily a pre-calibrated sharp-crested weir (as specified in IEC-60041) is very expensive and time-taking process. The job is relatively easier in case of a well-defined narrow-cross-section tailrace channel. The method has a large uncertainty of discharge measurement.

The pressure-time (Gibson) method requires fairly sophisticated instruments, instrumentation and evaluation software, but gives good results, that is, low uncertainty of measurement. However, engineer in-charge of operating power stations do not prefer the method because of the repeated and sudden closure of flow.

IEC-60041 recommends the use of ultrasonic transit-time flowmeter (UTTF) with intrusion type transducers for both penstocks and open channels. For ensuring low uncertainty of discharge measurement, at least four-paths, and often 8 or 16 paths, of ultrasonic beam are required. Increasing the number of paths helps to reduce the integration error in the calculation of discharge. The high cost of multi-path intrusion type UTTF and its installation are often not justified for testing small generating units. A clamp-on type UTTF with one or two paths of ultrasonic beams, presents a good comprise between cost and performance for measuring discharge in the penstocks of SHP stations. The remaining methods of discharge measurement listed above may not be convenient for use in the field.

Acoustic Doppler current profiler (ADCP) is a newer instrument, which was not commercially available at the time IEC-60041 was written and accepted. It is now available in horizontal-beam and vertical-beam versions, which can be conveniently used for determining water current (velocity) profile in a measurement section, and thus the discharge in open channels. The measurements are found in good agreement with those obtained from PCM method. The cost of ADCP is much lower than that of multipath intrusion-type UTTF. With proper calibration and use, ADCP can give similar (low) level of uncertainty of discharge measurement, as does the UTTF.

The choice of the methods, procedure of testing and the uncertainty of measurement depend significantly on the availability of appropriate provisions for the same in the plant equipment and civil works. The developers, engineering consultants, station designers and equipment manufacturers in India have been educated on the necessity and advantages of making the provisions like pressure taps on the turbine casing/penstock, an exposed and straight penstock section, weir in the tailrace, stilling wells in the headrace and tailrace and ensuring well-defined sections of the open channels.