HYDROELECTRIC HANDBOOK

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With the Assistance of Contributors

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Instead of deflecting the jet by means of the hinged deflecting nozzle, in the standard design the nozzle pipe and its needle control mechanism remain stationary and a sleeve-type deflector is provided between the bucket wheel and the nozzle orifice. This sleeve is actuated quickly by the governor, deflecting the jet partly or wholly on load rejections.

Where water-saving action is required the needle is interconnected either mechanically by means of a dashpot or hydraulically in such a manner that it follows the movement of the quick-acting jet deflector, at a rate, however, which prevents undesirable pressure variations in the pipeline.

Figure 44 shows a single overhung horizontal impulse turbine having one jet operating on the buckets and disk. The buckets and disk are mounted on the extended end of the generator shaft, the two generator bearings carrying the weight of the rotor and the impulse wheel. On this unit the regulating cylinder of the governor is connected directly to the needle, a governor-operated pressure regulator being provided so that when the needle is closed rapidly the pressure regulator opens simultaneously, preventing a serious rise in pressure. The pressure regulator then is caused to close slowly so that no more water will be wasted. Some reliable type of valve is usually required in an impulse-turbine plant as the penstocks are usually long and the pressure high. The majority of plants use a special type of gate valve, although there are some installations where the needle type of valve is used. (See also Chapter 39, Sections 17 and 18.)

Figure 46 shows an arrangement of a vertical-shaft impulse wheel where two jets are used on the one disk, a pressure regulator being provided to prevent serious pressure rises. The generator is arranged similarly to that for a cast-casing reaction wheel, the water being brought into the wheel through a penstock located below the floor. The revolving parts of the impulse wheel are covered in a waterproof chamber.

22. Efficiency Tests. Efficiency tests of turbines in hydraulic power plants are desirable and furnish valuable information regarding the performance of the power-generating equipment. With new installations, such tests determine whether the manufacturer's guarantees of efficiency and power have been met. If the efficiency is lower than the guarantee, there may be a serious economic loss over the period of the life of the turbine [20].

With old units, efficiency tests help to indicate whether the existing equipment should be replaced with more modern and efficient apparatus to utilize the available flow more economically. Often, as a result of testing, inefficient operating practices are discovered and corrected. If the efficiency of all or most of the units in a system is known the distribution of the load among the various generating units of the system in the most economical manner is greatly facilitated. Accordingly, periodic check-ups are often desirable. This is a very simple matter if some method of permanently measuring the discharge of the turbines is available. Otherwise it may be desirable to make complete efficiency tests on a unit at intervals of several years.

The operation of adjustable propeller blades in conjunction with the governor is usually checked at the time of the acceptance field tests to insure that the most efficient blade settings are used.

A complete efficiency test of a hydraulic turbine requires accurate measurements of the power output, head, and discharge at a sufficient number of gate openings so that curves of these values may be plotted. Such tests, to be reliable, should be made or supervised by men experienced in the various departments, as the conclusions drawn from test results are sufficiently important to warrant all possible care in the performance of the test. In tests of new units where there is an efficiency guarantee with or without penalties for nonperformance, the test procedure and the personnel in charge of the test should receive the sanction of the manufacturer. Also, a representative of the manufacturer should be present during the test.

In modern hydroelectric plants the power output of the turbine is usually measured electrically by measuring the output of the generator, using calibrated test instruments, transformers, and leads. Properly determined allowances are made for the various generator losses (see Section 5, Chapter 41).

The effective head on the turbine, on which efficiency computations are based, is the vertical distance from headwater to tailwater minus all losses down to the entrance of the scroll case and minus the velocity head in the tailrace at a point just below the draft-tube exit. (See Fig. 1, Chapter 9, "Head, Power, and Efficiency." Thus, for purposes of determining the efficiency of the turbine, only the losses in the turbine-casing, losses in the turbine itself, and the losses in the draft tube are considered.

The American Society of Mechanical Engineers Test Code (1938) provides (Paragraph 84) that

> The effective head on the turbine shall be taken as the difference between the elevation corresponding to the pressure head in the penstock at the entrance to the turbine casing and the elevation of tailwater; the above difference being corrected by adding the velocity head in the penstock at the section of measurement and subtracting the residual velocity head at the section of measurement in the tailrace.

The above applies to reaction turbines (Francis and propeller). In the case of impulse wheels, the effective head is generally taken as the pressure head at the entrance to the nozzle, plus the velocity head at this point.

The turbine discharge may be measured by one or more of several established methods as follows:

1. The Allen salt-velocity method, which utilizes the time required for a dose of salt solution to pass between two stations, the salt solution being detected by the variation in an electric current passing through the water.
2. The Gibson method, which utilizes the pressure variation in a pipeline caused by a change in flow.
3. The Pitot tube method, in which a calibrated Pitot tube is used to traverse a penstock.

4. The current-meter method, which utilizes calibrated current meters for traversing the headrace, canal, or tailrace.

5. The weir method, which involves the construction of a weir whose coefficient of discharge is definitely known, usually in the tailrace. If the weir is left in place this method involves a permanent loss of head.

6. The Venturi meter, which has the advantage of providing a permanent record of discharge. A Venturi meter is sometimes installed in the penstocks of high-head plants, but this method involves a permanent loss of head for the purpose of measuring the water. The Venturi principle may, however, be utilized for securing a constant record of discharge without any additional loss of head [19]. Any contraction, such as inlet to casing or the speed ring, produces a loss of head. By properly placing piezometers and carrying them to recording instruments, such as are manufactured by Builders Iron Foundry, Providence, R. I., and Simplex Valve and Meter Company of Philadelphia, Pa., a permanent record of discharge may be obtained provided calibration is made originally by some suitable method.

The most advisable method of discharge measurement is determined by the particular conditions of the development, and, before reaching a decision as to the method to be used, the matter should be discussed with the turbine manufacturers.

All efficiency tests should be made in accordance with the Test Code for Hydraulic Prime Movers, 1938, or a later revision thereof, published by the American Society of Mechanical Engineers, New York City.

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