Combination of Francis and Pelton Turbines on a Pressure Pipe Line for an Optimal Utilization of Highly Variable Water Volumes

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Introduction

In order to be able to optimally handle fluctuating amounts of water in hydropower utilisation, the double-regulated Kaplan turbine was developed in the low-pressure range. For medium head ranges, single-regulated turbines (Francis) are normally used. From this, however, partially results the problem, not to be able to react to the different amounts of water (e.g.: for mountain streams) in a suitable manner. GLOBAL HYDRO ENERGY GmbH has developed the optimal solution for this problem and implemented it in practice in a pilot project. For that, the two turbine types Francis and Pelton are used jointly within a powerhouse.

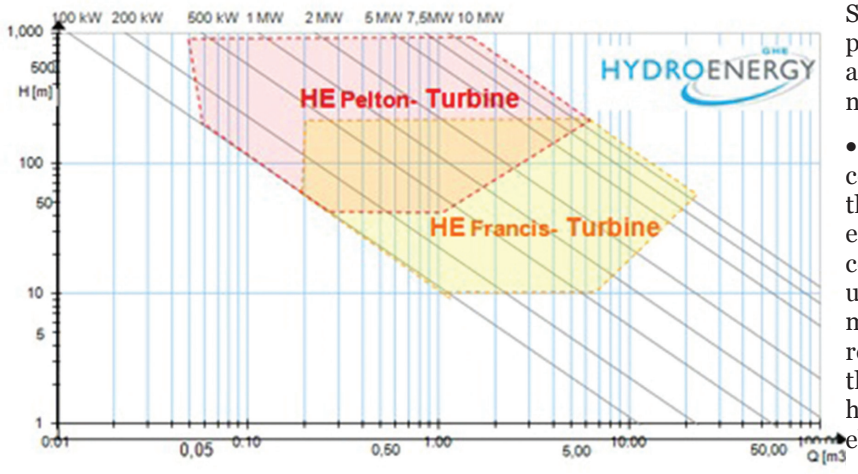
The combination of Francis and Pelton turbines has not been a popular solution in the turbine industry for high-pressure plants up to now. Both types of turbines possess various advantages and disadvantages in their respective fields of application. The Francis turbines feature extremely good peak efficiency at full load. The advantage of Pelton turbines, on the other hand, is demonstrated when different water volumes have to be processed. Therefore it stands to reason to ask whether a combination of Francis and Pelton is technically possible and what benefits such a combination might entail.

Area of application:

A sensible joint utilization of both types of turbines within a power plant is limited primarily by their differing ranges of heads of water.

Francis turbine: 10 - 200 m (depending on the flow)

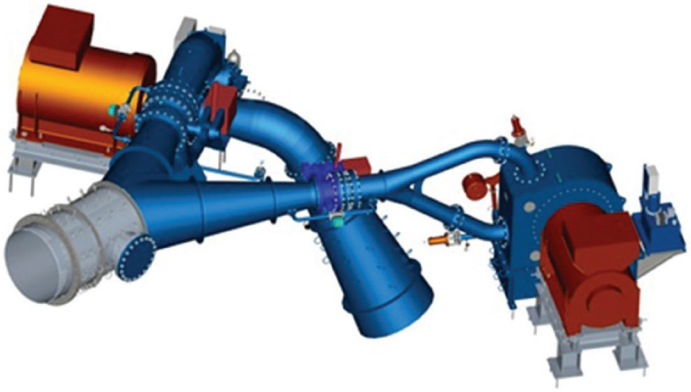
Pelton turbine: 60 - 1,000 m (depending on the flow)



Hence, in the range of 60–200 meters, in which the two types overlap, a potential exists of utilizing Francis and Pelton jointly on a pressure pipe line. Mountain streams with a highly variable water supply due to snowmelt and climatic influences constitute the preferred area of application for this solution.

Benefits

- Optimal utilization of the water volume existing at any one time by dint of the option of operating both turbines jointly, as well as-depending on the water volume available-operating only a single turbine at a time. With the Pelton facility, naturally, there is the option of varying the number of nozzles. For the project as a whole, this entails a possible flow reduction of less than 5% of the entire design inflow.
- Optimal efficiency: Both turbines in combination are laid out in such a manner that an uninterrupted transition between Francis and Pelton commences upon admission. If the water volume sinks, the transition from the Francis turbine to the Pelton turbine occurs at a point in time when the admission of the Francis still amounts to 40%. Thus the effective efficiency level of the entire plant remains continually over 80%.
- Therefore, the generation of electricity can take place at an optimal efficiency over the course of a year. The two turbines will be operated jointly during snowmelt in spring; subsequently, a gradation by aid of the Pelton nozzles will occur. From a total admission of around 2/3 of the design inflow on, the Pelton turbine will be switched off. If the water volume sinks even more, the transition from Francis to Pelton takes place. Subsequently, the available water is processed optimally again by opening an appropriate number of Pelton nozzles.
- Another advantage of this combination is entailed in the fact that uninterrupted downtimes will ensue for each turbine over the course of a year. This time can be utilized optimally for conducting maintenance work that might be required on the respective facility that has been switched off without having to interrupt the generation of electricity.
- Owing to the differing features of these two types of turbines, minimum values of surges will be attained with a joint

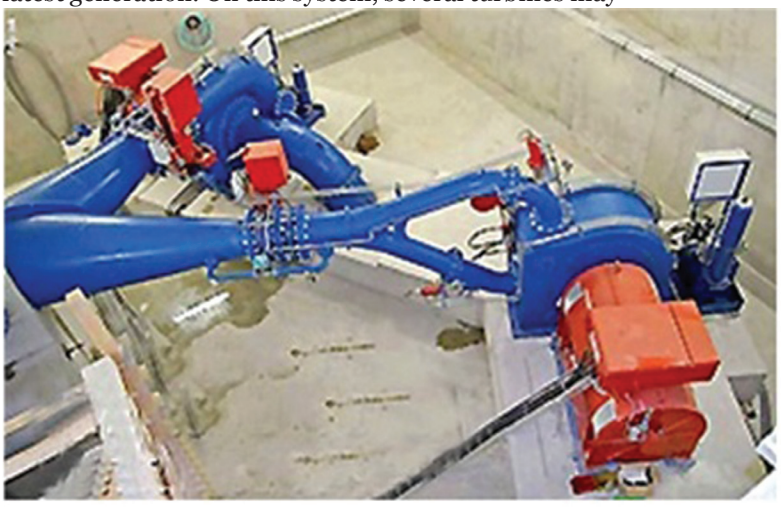


operation, even in the case of an emergency shutdown. This, in turn, significantly heightens the safety of the system as a whole.

Prerequisite

The prerequisite for a successful operation of such a plant is the intelligent control of both turbines by the aid of a digital turbine control and power plant automation, which guarantees a fully automated control of the entire system on the basis of water-level controls and performance controls. A well-arranged visualization of the individual statuses as well as the possibility of a remote access and of an alarm system help the operator should a manual intervention in the system become necessary.

The digital turbine control HEROS of the company GLOBAL HYDRO ENERGY GmbH is a Windows-based solution, which is installed on an industrial PC of the latest generation. On this system, several turbines may



also be controlled in parallel. Therewith, this control enables an optimal overview over the condition of both turbines. An intervention into the core parameters (e. g. water quantity distribution, etc.) for optimisation of the power production is possible any time without any problem. Monitoring and control of the ancillary plants, like hydraulic aggregates, generators, hydraulic steel structures likewise take place via the HEROS system. Therewith, fully automatic operation of the entire powerhouse or inlet area, respectively, is guaranteed. In case of possible incidents, the power plant operator is sufficiently informed via SMS. Any relevant information and conditions of the system are continuously archived and are available for the operator anytime.

The combination of Francis and Pelton turbines in a power plant offers numerous advantages to the operator, despite the limited area of application. The relatively high investment costs for high-pressure plants demand the exploitation of optimal performance levels and generation of electricity alike from the available water volumes. This solution definitely contributes to a comprehensive improvement of the profitability and amortization of such projects.

As a full-range supplier of hydropower plants up to 10 MW, HYDRO ENERGY offers their customers extensive experience in the planning, production, start of operations and control of such double plants.

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References

1. HPP Märzenbach, Austria, 2009

Francis Turbine: Turbine output PT = 1640 kW, net head: HN = 134,00 m, discharge: Q = 1,40 m³, Runner outlet diameter ~ 480 mm

Pelton Turbine: Turbine output PT = 685 kW, net head: HN = 134,00 m, discharge: Q = 0,58 m³, Jet circle diameter ~ 770 mm

2. HPP Sebes 3, Romania, 2010

Francis Turbine: Turbine output PT = 1078 kW, net head: HN = 93,8 m, discharge: Q = 1,30 m³, Runner outlet diameter ~ 469 mm

Pelton Turbine: Turbine output PT = 515 kW, net head: HN = 93,8 m, discharge: Q = 0,63 m³, Jet circle diameter ~ 919 mm