OPTIMAL OPERATION OF RUN OF RIVER SMALL HYDRO POWER PLANT

Ph.D. THESIS

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ABSTRACT

Energy is the basic input for the economic development of a country. The growing demand for energy generation has resulted in dependency on fossil fuels. The price of fossil fuels and security of energy supply has been a concern in India and other countries which can be overcome by the exploitation of large potential of hydro power and renewable energy sources. Small hydropower (SHP) plants mostly run of river type have less environmental impact as compared to large hydro. In India, hydro power schemes upto 25 MW are under SHP category. To harness maximum energy during the life of SHP plant, proper operation is very important. In such schemes, head is normally constant but there is large variation in the discharge as per availability of run off, thus, proper operational strategy is required to harness maximum energy under variable discharge conditions.

From detailed literature review, it is found that lot of work has been carried out on various techniques for operation of large hydro power plants. However, few studies are available on operation and planning of small hydro power plants, because such plants utilize direct form of water which is a complex system at real time. The present study has been carried out to develop a strategy for optimal operation of run of river small hydro power plant with the following objectives;

1. To study operational aspect of SHP plant through field survey of such plants.
2. To identify and investigate system and operating parameters affecting operation.
3. To investigate different operating conditions for maximum utilization of power potential.
4. To collect the field data and investigate the effect of identified parameters on energy generation under different operating conditions.
5. To analyse and develop optimal operation strategy of SHP plants based on maximum energy generation and minimum operation cost.

In order to achieve these objectives, some running SHP plants in India were studied and found that the streams have variation in the flow throughout the year, which affect the energy generation as well as the operation. There are various operation and system parameters which affect the operation of such plants. Under the present study, multi attribute decision making (MADM) approach has been used to find out the most critical parameters for operation through decision matrix and graphical representation approach. Critical parameters such as discharge, head, efficiency, head loss, and number of turbines have been

investigated from operation point of view and considered for further analysis for optimal operation. Based on the identified operating parameters, discharge is found to be the most critical for generation of energy. So, analysis has been carried out taking the discharge as a critical parameter. The analysis has been made for optimal generation by using different operation strategies. The operation conditions are; when the available discharge is maximum, then all machines are running at their rated capacities. If the discharge is less, then there are options to operate the machines in such a way that one machine may operate at full load and other machines operate at part load.

Different combinations of capacity and number of turbines have been analysed to investigate the maximum energy for each case. From the flow duration curve, the maximum potential of selected site is found to be 9119 kW. Various combinations of discharge distribution were analysed to obtain maximum energy under different capacities and combination of units. It has been found that an installation of 6 MW will be optimum considering different combinations based on number of generating units.

There are other operating parameters also, which affect energy generation directly. Discharge, head, head loss, efficiency and number of generating units have been identified and considered for analysis of energy generation in order to develop the operational strategy. The field data have been collected from 39 SHP plants identified in different states throughout the country (India) by visiting the plants. The energy generation values have been computed for different conditions and expression was developed by nonlinear curve fitting technique in MATLAB code. The developed expression has been validated with the energy data of 20 other sites. The maximum deviation has been found as ± 4.74%. For the optimal operation of SHP plant, it is necessary to compute the operating cost with respect to the energy. In order to obtain expression, the data for operating cost has been collected and analysed considering head and capacity as cost influencing parameters. The developed co-relation for operation cost has been validated for its accuracy.

In order to achieve optimal operation, the analysis for operation strategy has been carried out considering maximum energy generation at minimum operation cost by using a nonlinear constrained algorithm (NLC) is applied. The NLC algorithm has been coded in MATLAB for their two subsequent algorithm through interior point method (IPM) and sequential quadratic programming (SQP) algorithm for which annual energy and operation cost have been considered as objective functions.

The objective function and the optimum value of operation parameters as discharge, head, efficiency, head loss and number of units are found to be 18 cumecs, 700 m, 0.97, 2 m, 4 units respectively. It is also found that a small hydro power plant of 5 MW capacity will be optimally operating for generating total energy of 20.29 MU at minimum annual operation cost ₹ 3608 per kW.

The developed co-relation for estimation of operation cost, co-relation for energy estimation and methodology for optimum values of operating parameters and operation cost shall be useful for researcher, planner, decision maker and developers of SHP plants.