Abstract

High penetration wind-diesel hybrid power systems, in which the average wind power generation, can approach or even exceed the average load, require much more sophisticated controllers and more expensive components in addition to the wind turbines. Different researchers approached the optimal design (in the sense of minimum energy cost) and operation problem for these high penetration stand alone systems from different perspectives. However, to the best of the author's knowledge, no attempt has been made so far to optimize the sizes of the power electronic converters and the induction machine of a hybrid wind-diesel stand-alone power generation system in a site specific manner. Particularly, the reactive power demand (by the load as well as the induction generator) from a stand-alone wind power generating system has not been considered for calculation of the power converter ratings.

Hence an attempt is made in this thesis to optimize the component ratings of a 'wind only' as well as a hybrid wind-diesel stand alone generator so as to produce electrical power at the minimum cost. To this end, the maximum power output from a Double Output Induction Generator (DOIG) based wind power generating system with varying component ratings is determined under several technical equality (including the reactive power allocation) and inequality constraints. The maximum power extractable from a DOIG based system is also experimentally verified on a laboratory prototype. The components of a stand alone 'wind only' system is then optimally sized for different Indian sites,. The optimum combinations of the system components are found to be strongly influenced by the wind velocity and, to a lesser extent, by the load reactive power profiles.

The thesis then focused on the optimal design of a hybrid wind-diesel system. An active power sharing algorithm between the generators is proposed ensuring (a) maximum power tracking by the wind generator, (b) minimum 40% loading of the diesel

generator when committed, and (c) minimum 95% of the overall load energy demand is met. A reactive power sharing algorithm is also proposed so as to shift the reactive load to the diesel generator till the alternator current limit is reached. The optimum sizes of the wind and the diesel generators show that the diesel engine rating can be even less than the maximum load demand. The optimum downstream component sizes in a hybrid wind power generation system (i.e. DOIG, power converters) which are different from those for the wind alone generation system are found to maintain a nonlinear relationship with the sizes of the generators. This observation underscores the importance of site specific optimization of *all the components* of a hybrid system.

The hybrid system operation according to the active and reactive power share algorithm mentioned earlier was verified experimentally in real time on an extensive laboratory prototype. Different wind velocity and load transient conditions were simulated on the laboratory prototype. It was concluded that the optimum sizes of the components of the hybrid system are sufficient to absorb normal wind velocity and load transients while operating along the minimum cost trajectory.

Key-words: Wind Energy Conversion System, Double Output Induction Generator, Hybrid Power Generation, Optimization, Stand-Alone Generation.