Title of Doctor of Philosophy (Ph. D) Thesis:

Economic Dispatch Studies on Electric Power Systems

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Economic dispatch is defined as the process of allocating generation levels to the generating units in the mix, so that the system load may be supplied entirely and most economically. To all intents and purposes, there has been concern that optimum economic dispatch was not the best environmentally. On the other hand, existing capacity is a source of most pollutant emissions, and technological change has opened up opportunities for producing electricity in a cleaner and cheaper manner. In the context to increasing public awareness of the environmental situation and the plea for clean air, many organizations came up with a new method so called minimum emission dispatching method to reduce air pollution. However, this leads to a noticeable increase in the operating cost. In view of modern stringent requirements imposed on electric utilities and sluggish growth in demand, the power industry planners are indicating stronger trends towards supplying electric power of higher quality by improving the system security and the impact on the environment in parallel with pursuit of economy. Therefore, in order to obtain a more meaningful and practical optimal schedule of operation for power system, a study on economic load dispatch is conducted in multi-objective framework where operating cost and NO_X emission objectives are undertaken simultaneously.

Despite extensive research focusing on optimal power scheduling problems, much of the effort to date has involved the development of deterministic models applicable to steady-state conditions. Most of these attempts assume the system data to be deterministic. It means that all input information is known with complete certainty. Actually, there are several inaccuracies and uncertainties in the input information. The economy of operation of power systems is significantly influenced to a certain degree by approximations in the operation planning procedures and by the inaccuracies and uncertainties in input system information. By way of this study, a theoretical basis and methodological grounding for the optimal dispatch problem in a unified multi-objective framework is established by giving quantitative representation of inaccuracies and uncertainties in input data for more realistic approach. The need for such a study comes from the fact that the very sophisticated procedure might show unexpected deviations on realistic small error in the input datum.

The thesis briefly reviews the past work in the area of optimal power dispatch along with the introductory description of multi-objective optimization techniques. A classical multi-

objective dispatch problem has been defined with explicit recognition of uncertainty in system production cost data and random nature of load demand. The probability properties are assumed to be known from past history. The stochastic models are reduced to their deterministic equivalents using Taylor's series. The novel formulation encompasses variance of generation mismatch as another objective to be minimized. The ε-constraint method is put in practice to generate trade-off between objectives. The computational implementation is based on Newton's iterative procedure with special initial guess. Further, the Surrogate worth Trade-off method has been exercised ingeniously to find the compromised solution for multi-objective optimization problem for more than two objectives. In the ensuing chapter, the existence of correlation of random variables is elegantly investigated in the formulation of multi-objective decision making problems while considering uncertainties. The simplest weighting technique is described to generate non-inferior solutions. The fuzzy set theory is exerted to attain the compromised solution from non-inferior solutions.

The succeeding chapter extends the multi-objective problem formulation exploiting fuzzy set theory to manipulate the security constraints and generation limits, which are recognized in the form of objectives besides the economy and NO_X emission objectives. Artificial Neural Network is employed to obtain the optimal generation dispatch whilst the training is achieved adopting back-propagation algorithm. The three layered feed forward neural network is trained to capture the preference. Virtually, the multi-objective formulation is amenable to sensitivity analysis by specifying sensitivity index that is a function which indicates the relative size of the perturbations in their solution due to variations in the parameters. In view of this, the author is motivated to add a new chapter by aiming dispersion index as sensitivity measure for the investigation of the effects of random variations in model parameters of the optimal solution. A sensitivity trade-off is exploited for multi-objective problem that represents the trade-off between sensitivity and objective level.

A decision making methodology is next illustrated to determine the optimal generation scheduling for hydro-thermal system with multiple conflicting objectives with due consideration of uncertainties in production cost data, system load demand and hydro reservoir water inflows. In deciding the optimal operation, three objectives operating cost, NO_X emission and unsatisfied load demand are simultaneously minimized since generator output is random. Specific technique is put forth to convert the stochastic models into their deterministic equivalents. A set of non-inferior solutions is generated through weighting method. In the continuation of work, short-range fixed-head hydro-thermal problem is considered. The Newton-Raphson method with special initial guess is utilized to get the solution. The optimal scheduling of long-term hydro-thermal problem is tackled next in which decomposition technique is employed to solve optimization problem. In each sub-interval hydro sub-problem is solved separately using conjugate gradient method and thermal sub-problem using efficient method.

The validity and effectiveness of the whole study in the thesis has been extensively verified and numerically tested by analyzing sample systems having several generators. Finally, the main conclusions of the thesis are presented and future lines of research are indicated.