CHAPTER 2

REVIEW OF LITERATURE

Power flow study has been modelled and suggestions provided by many research analysts have paved the way for self-healing smart grids. On analysis of such algorithms, they have only given suggestions to their study that they have simulated and it is not modelled for common purpose or general utility. The ability to control power flow is critical, as it very essential in matching the demand with the generation. The utility should directly draw the power from generator and the demand should be matched in smooth transition, without any discrepancies. For that comparing all the load flow analysis and suggesting the best algorithm for general utility is need of the hour. An exhaustive review of literature on dynamic ED, emission constrained ED, multi-area ED, multi-area DCOPF, multi-area ACOPF and security constrained OPF reports that many conventional mathematical optimization methods and methods based on Artificial Intelligence (AI) have been applied to solve these problems.

In 1990, N.I.Santoso et al., presented a two-stage Artificial Neural Network to control in real time the multi tap capacitors installed on a distribution system for a nonconforming load profile such that the system losses are minimized. The required input data are directly obtained from on-line measurements which include the active and reactive line power flows, voltage magnitudes and the current capacitor settings at certain buses. Inequality constraint consists of limits on capacitor rating. The application of the proposed capacitor control will be limited by the computation time required for the learning process which in turn depends on the number of conforming load groups and capacitors installed rather than the number of system buses.

In 1992, Chowdhury et al., had suggested concept of Integrated Security Constrained Optimal Dispatch (ISCOD) which could solve the OPF problem when it was constrained by both static and dynamic security. ISCOD utilized the diagnostic and decision making capabilities of Knowledge Base System (KBS), massive parallelisms and learning features of an ANN along with conventional power system network solution methodologies to provide real-time control and optimization. The KBS and
the ANN are used in different configuration for adding the dispatch or in making control decisions.

During the same period, Miranda et al., developed a fuzzy model to represent uncertainty in loads and generation as fuzzy membership functions, while uncertain injections were dealt with DC power flow model. Optimal solution was computed with Dantzing-Wolfe decomposition technique and dual simplex method. The algorithm calculates fuzzy cost value for system operation, branch power flow and power generation. Also, David C. Walters et al., applied a Genetic Algorithm (GA) to solve an economic dispatch problem for valve point discontinuities.

In 1993, Chowdhury et al., proposed Expert System (ES) which was used in combination with a transmission constrained economic dispatch to provide real time security. The strategy for combining the ES with an economic dispatch which identifies the constraint violations in bus voltage magnitudes and in line flows, as well as the set of optimal generations. The ES then determines the best possible control measure using rules on voltage and line flow control. The purpose of the expert system is to expeditiously remediate voltage and branch over load problems.

In 1995, Po-H.Chen et al., proposed a new genetic algorithm for solving the Economic Dispatch (ED) problem in large-scale systems. A new encoding method is developed in which the chromosome contains only an encoding of the normalized system incremental cost. So the total number of bits of chromosome is entirely independent of the number of units. The approach can take network losses, ramp rate limits and prohibited zone avoidance into account. It is faster than lambda – iteration method in large systems.

Also, Dr.Eberhart and Dr. Kennedy developed Particle swarm optimization method; a population based evolutionary computation technique; the velocities of the individual particles are stochastically adjusted according to the historical best position for the particle itself and the neighbourhood best position at each iteration. Both the particle best and the neighbourhood best are derived according to user defined fitness
function. The movement of each particle naturally evolves to an optimal or near-optimal solution.

During 1996, F.D. Galiana and K. Almeida, preferred FACTS Devices due to its overall performance based on the assessment of impact of FACTS Devices on power system performance, this technology is preferred in bringing a system under control, transmitting power as ordered by control centre economically and allowing increase usable transmission capacity to its maximum thermal limits.

In 1997, Song et al., proposed a modified genetic algorithm which incorporates fuzzy logic controllers for adjustment of crossover and mutation probabilities for obtaining much better optimal solutions when applied to the combined environmental constrained economic dispatch. Also, proposed dispatched dynamic load dispatch with voltage security and environmental constraints.

During the same period, V.C.Rameshet al., presented a Fuzzy Logic approach for the contingency constrained OPF problem formulated in a decomposed form that allows for post-contingency corrective rescheduling. Linear membership function is used. The formulation treats the minimization of both the base case (pre-contingency) operating cost and of the post-contingency correction times as conflicting but fuzzy goals. The proposed approach can yield Pareto curves that can guide the system operator regarding the tradeoff between cost and security against contingencies. However, choice of a suitable metric for measuring correction time is unclear.

In 1998, Yalcinoz T. et al., proposed an Neural Networks for solving economic dispatch problems with transmission capacity. Also, Van Cutsem T, et al., proposed that voltage stability, regarded as one of the main concerns to maintain system security, is the ability of the power system to maintain acceptable voltage profile under normal conditions and even after being subjected to disturbances.

In 1999, N.G.Higorani et al., introduced the concept of FACTS controllers by the EPRI for improving the utilization of the existing power system. In electric power system, the FACTS are applied for the control of power flow, improvement of stability, voltage profile management, power factor correction and loss minimization.
In 2000, Narayana Prasad Padhy et al., solved the OPF problem using Dynamic programming. The OPF problem includes uncertainty in the load demand using fuzzy logic and with the inclusion of Thyristor Controlled Series Capacitor (TCSC) for effective system operation. The uncertainty in the load demand results in higher generation cost at the most feasible operating point compared to the cost when the uncertainty in the load demand is not considered. With the inclusion of TCSC, the total generating cost is less than that obtained without TCSC.

During the same period, H.Mori et al., presented a Parallel Tabu Search (PTS) based method for determining optimal allocation of FACTS devices in competitive power systems. Available Transfer Capability (ATC) was maximized with the FACTS devices. UPFC was modeled and concept of incremental load rate was used. The proposed method was compared with Simulated Annealing, GA and Tabu Search methods. It is 1.95 and 2.68 times faster than TS and GA respectively. It is not affected by the initial conditions and gave higher quality solutions.

Also, H.Yoshida et al., proposed a Particle Swarm Optimization (PSO) for reactive power and Voltage/VAR Control (VVC) considering voltage security assessment. It determines an on-line VVC strategy with continuous and discrete control variables such as AVR operating values of generators, tap positions of OLTC of transformers and the number of reactive power compensation equipment.

In 2001, to achieve voltage security enhancement, the contingency state voltage stability index is included as additional constraint in the formulation of OPF problem along with the contingency state constraints proposed by Canizares C. et al.

During the same period, T.S.Chunget al., presented a Hybrid Genetic Algorithm (GA) method to solve OPF incorporating FACTS devices. GA is integrated with conventional OPF to select the best control parameters to minimize the total generation fuel cost and keep the power flows within the security limits. TCPS and TCSC are modelled. The proposed method was applied on modified IEEE 14 bus system and it converged in a few iterations.
Also, I.K. Yu et al., presented a novel co-operative agents approach, Ant Colony Search Algorithm (ACSA)-based scheme, for solving a short-term generation scheduling problem of thermal power systems. The state transition rule, global and local updating rules are also introduced to ensure the optimal solution. Once all the ants have completed their tours, a global pheromone-updating rule is then applied and the process is iterated until the stop condition is satisfied. The feasibility of the algorithm in large systems with more complicated constraints is yet to be investigated.

In 2002, Hesham K. Alfares and Mohammad Nazeeruddin made a survey over load forecasting in electric power system and classified it under ten categories.

In 2003, Zhu proposed a penalty minimizing-neural network approach to solve security constrained multi-area ED. The security constrained multi-area ED has tie-line security constraint in each area and a simple buying and selling contract in multi-area environment.

During the year 2004, Abdel Moamen Mohammed, Abdel Rahim Ahmed researched over the optimal power flow with FACTS Devices. Also, N.P. Padhyw et al., presented an efficient hybrid model for congestion management analysis for both real and reactive power transaction under deregulated Fuzzy environment of power system. The proposed model determines the optimal bilateral or multilateral transaction and their corresponding load curtailment in two stages. In the first stage classical gradient descent OPF algorithm has been used to determine the set of feasible curtailment strategies for different amount of real and reactive power transactions. In second stage, fuzzy decision opinion matrix has been used to select the optimal transaction strategy.

Also, Masoum et al., proposed a fuzzy-based approach for optimal placement and sizing of fixed capacitor banks in radial distribution networks in the presence of voltage and current harmonics. The objective function includes the cost of power losses, energy losses, and capacitor banks.

In 2004, L.J. Cai et al., proposed optimal choice and allocation of FACTS devices in multi-machine power systems using genetic algorithm. The objective is to
achieve the power system economic generation allocation and dispatch in deregulated electricity market. The locations of the FACTS devices, their types and ratings are optimized simultaneously. UPFC, TCSC, TCPST and SVC are modeled and their investment costs are also considered.

Also, P.Somasundaram et al., proposed an algorithm for solving security constrained optimal power flow problem through the application of EP. The controllable system quantities in the base-case state are optimized to minimize some defined objective function subject to the base-case operating constraints as well as the contingency case security constraints. Fitness function converges smoothly without any oscillations.

Also, Libao Shi et al., presented ant colony optimization algorithm with random perturbation behaviour (RPACO) based on combination of general ant colony optimization and stochastic mechanism is developed for the solution of optimal unit commitment (UC) with probabilistic spinning reserve determination. Total production fuel costs, start-up costs of units in stage t, the penalty cost imposed when any of constraints are violated and the total accumulated cost from stage 0 to stage t. are included in objective function. The security function approach is also applied to evaluate the desired level of system security.

In 2005, R.Meziane et al., used ACO to solve the allocation problem involving the selection of electrical devices and the appropriate levels of redundancy to maximize system reliability of series-parallel topology, under performance and cost constraints. A universal moment generating function (UMGF) approach is used by the ACO to determine the optimal electrical power network topology.

In 2005, Debanjan Ghosh et al., surveyed and synthesised the concept of Self-healing systems, that attempt to “heal” themselves in the sense of recovering from faults and regaining normative performance levels independently the concept derives from the manner in which a biological system heals a wound. Such systems employ models, whether external or internal, to monitor system behavior and use inputs obtaining therefore to adapt themselves to the run-time environment. Researchers
have approached this concept from several different angles this paper surveys research in this field and proposes a strategy of synthesis and classification. Also, N.P. Padhyetal., detailed the power flow control and solutions with multiple and multi-type FACTS devices.

During the same period, W.Ongsakulet al., proposed Evolutionary Programming (EP) to determine the optimal allocation of FACTS devices for maximizing the total transfer capability (TTC) of power transactions between source and sink areas in deregulated power system. EP simultaneously searches for FACTS locations, FACTS parameters, real power generations except slack bus in source area, real power loads in sink area and generation bus voltages.

Also, P.Attaviriyanupapetal., presented a new bidding strategy for a day-ahead energy and reserve markets based on an EP. The optimal bidding parameters for both markets are determined by solving an optimization problem that takes unit commitment constraints such as generating limits and unit minimum up/down time constraints into account. The proposed algorithm is developed from the view point of a generation company wishing to maximize a profit as a participant in the deregulated power and reserve markets. Separate power and reserve markets are considered, both are operated by clearing price auction system.

Also, T.Jayabarathiet al., proposed the application of Classical Evolutionary Programming (EP), Fast EP and Improved FEP methods to solve all kinds of economic dispatch problems such as ED of generators with prohibited operating zones (POZ), ED of generators with piecewise quadratic cost function (PQCF), combined economic environmental dispatch (CEED) and multi-area economic dispatch (MAED). The constraints considered are the power balance, generating capacity, prohibited operating zones, area power balance, generation limits and tie-line limits constraints.

In 2005, Jong-Bae Park et al., suggested a Modified Particle Swarm Optimization (MPSO) for economic dispatch with non-smooth cost functions. A position adjustment strategy is proposed to provide the solutions satisfying the
inequality constraints. The equality constraint is resolved by reducing the degree of freedom by one at random. Dynamic search-space reduction strategy is devised to accelerate the process. The results obtained from the proposed method are compared with those obtained by GA, TS, EP, MHNN, AHNN and NM methods. It has shown superiority to the conventional methods.

In 2005, Cui-Ru Wang et al., presented a Modified Particle Swarm Optimization (MPSO) algorithm to solve economic dispatch problem. In the new algorithm, particles not only studies from itself and the best one but also from other individuals. By this enhanced study behaviour, the opportunity to find the global optimum is increased and the influence of the initial position of the particles is decreased. The particle also adjusts its velocity according to two extremes. One is the best position of its own and the other is not always the best one of the group, but selected randomly from the group.

In 2005, J.G.Vlachogiannis etal., formulated the contributions of generators to the power flows in transmission lines as a multi-objective optimization problem and calculated using a Parallel Vector Evaluated Particle Swarm Optimization (VEPSO) algorithm. VEPSO accounts for nonlinear characteristics of the generators and lines. The contributions of generators are modelled as positions of agents in swarms. Generator constraints such as prohibited operating zones and line thermal limits are considered. It can obtain precise solutions compared to analytical methods.

In 2006, Mekhamer, S.F. et al., used simulated annealing approach to solve the practical aspects of capacitors, load constraints and operational constraints at different load levels.

In 2007, M.Saravanan etal., proposed the application of Particle Swarm Optimization to find the optimal location, settings, type and number of FACTS devices to minimize their cost of installation and to improve system loadability for single and multi-type FACTS devices. While finding the optimal location, the thermal limit for the lines and voltage limit for the buses are taken as constraints. TCSC, UPFC and SVC were considered. Also, Chang et al., developed a fuzzy based
approach for the placement of the shunt capacitor banks in a distribution system with considering harmonic distortions

In 2008, Basu M. proposed a Differential Evolution for optimal power flow with FACTS devices. Also, Pandya K.S et al., surveyed the various optimal power flow methods.

Also, AlRashidi, M.R., et al., highlighted the PSO key features and advantages over other various optimization algorithms and also discussed PSO possible future applications in the area of electric power systems and its potential theoretical studies.

2010, Manisha et al., explored the ability of differential evolution, classical Particle Swarm Optimization and Particle Swarm Optimization with time varying acceleration coefficients on a multi-area economic dispatch problem with tie-line constraints, non-convex and discontinuous fuel cost functions. The comparative analysis of these techniques reports the superiority of Particle Swarm Optimization with time varying acceleration coefficients.

In 2011, T.Bensley et al., proposed a technique for implementing new configurable Self-healing Smart Grid Technology with an existing Distribution Management system (DMS).

Also, John A. Stankovic discussed the basis for open research problems in IoT, a vision for how IoT could change the world in the distant future followed by enumeration of eight key research topics and research problems.

In the above indicated enormous literature review pertaining to ED problem using unit’s active power generation as decision variables and fuel cost as objective function, various conventional deterministic mathematical optimization techniques and numerous stochastic algorithms were proposed. The critical drawback of the proposed conventional deterministic mathematical optimization techniques are complexity and high computation burden for large scale systems and for stochastic algorithms the large number of iterations leading to very large computation time.
Normal Load flow analysis are easy to understand and simple to implement as compared to analytical and numerical programming methods. However, the results produced by these algorithms are not guaranteed to be optimal. The recent popularity of Artificial Intelligence (AI) has been investigated for its use in optimal D-FACTS allocation and other Engineering problems. Such AI based methods are Expert Systems (ES), Simulated Annealing (SA), Tabu Search (TS), Artificial Neural Networks (ANN), Genetic Algorithms (GAs), and Fuzzy set theory. Artificial intelligence techniques try to simulate human behaviour. They present a better, faster and accurate solution to an optimization problem than the existing conventional techniques. Artificial intelligence techniques generally make use of multiple solutions to obtain an optimal solution.