1. LITERATURE REVIEW OF REACTIVE POWER PLANNING

2.1 INTRODUCTION

Power is one of the most essential objects and has paramount importance in our country. With the improvement of quality social life requirement of power is growing as well. In a developing country like India, the requirement of power is considerable. The requirement of power is unimaginable so as the loss of power is also unimaginable. Power normally generated in a place quite far from the consumers or load area. To send power from generation station to our door step, a system called power system is used.

Power system is a combination of three subsystems called generation, transmission and distribution. The transmission is to deliver bulk power from power stations to the load centers and large industrial consumers beyond the economically service range of regular primary distribution lines whereas distribution systems is deliver power from power stations or substation to various consumers.

2.2 reactive power planning

The key of reactive power planning (RPP) or VAR planning is the optimal allocation of reactive power sources considering location and size. Optimal allocation of VAR sources, such as capacitor banks, static VAR compensation (SVC) and FACT devices like TCSC and UPFC, is a critical component in reactive power planning or VAR planning. Traditionally, the locations for placing new VAR sources were either simply estimated or directly assumed due to the complicated objective function, constraints, and solution algorithms; RPP is identified as one of the most challenging problems in power systems [87].

The following assumptions are considered while formulating the VAR planning problem in literature.

- The system is balanced
- The active and reactive power represents fundamental frequency powers, and additional powers as harmonic frequencies are negligible.
- The size of the VAR source is treated as a continuous variable. However, it is in fact discrete.
2.2.1 Objective of reactive power planning

The objective function of reactive power planning or VAR planning may be cost based. It minimize the possible cost associated with RPP such as variable and fixed VAR installation cost, real power loss cost, and/or fuel cost. Other possible objective may be to minimize the deviation from a given schedule of a control variable or to maximize voltage stability margin. It is also reasonable to use a multi-objective (MO) model as the goal of the RPP formulation.

2.2.2 Constraints of reactive power planning

The constraints in RPP are much more complicated than the objective functions. Conventional constraints may include the normal state power flow limits and the contingency state power flow limits [81]. However, more recent works proposed to include the voltage stability limits. Under both normal state and contingency state due to the increased pressure of voltage stability and stressed transmission systems. These different constraints are the key of the classification of various optimization models, identified as Optimal Power Flow (OPF) model, Security Constraint OPF (SCOPF) model and SCOPF with Voltage Stability Constraints (SCOPF-VS), the present state of the art in RPP[99].

2.3 REVIEW OF OPTIMAL REACTIVE POWER PLANNING METHODS

A number of methodologies have been proposed for Optimal Reactive Power Planning (RPP) in a power system over last few decades [94]. The formulations are constrained by limits on generator bus voltage, reactive power of VAR sources, tap setting of tap changing transformers, load bus voltages and generator reactive power outputs usually. The control variables are used in the formulation use a subset from the overall list of controllers comprising the generator bus voltages, the reactive powers of VAR sources, the tap setting of tap changing transformer and the load bus voltages. Numerous techniques have been proposed in the literature to solve the reactive power planning problem. They are categorized into the following three groups:

- Mathematical programming techniques
- Artificial intelligence techniques
- Evolutionary computation techniques

2.3.1 Mathematical programming techniques
Abdul-Rahman (1994) presented a solution to the Fuzzy security constrained optimal reactive power planning taking into account the non-probabilistic uncertainty associated with the reactive power demand. The objective is minimizing the real power loss and the allocation cost of new reactive power source.

Aoki et al (1998) proposed a recursive mixed integer programming technique by using an approximation method to solve reactive power planning. In this paper the number of capacitors or reactor units is treated as discrete variable in solving large scale VAR planning problem.

Bruno COVA (1995) presented a preventive secure contingency constrained approach to the voltage profile optimization suitable both for VAR planning and short term reactive scheduling. The solution to the problem is based on the two optimal reactive power flow is discussed.

Chebbo et al (1992) proposed a voltage collapse proximity indicator at the load points of the power system based on the optimal impedance solution at maximum power transfer.

Chen et al (2004) proposed the multi objective VAR planning problem was solved by the projection based two-layer simulated annealing algorithm for a large scale power system. The objective function of the reactive power planning Problem includes active power loss, the investment cost of VAR sources and voltage divergence. The study presents minimizing each motive simultaneously while satisfying the constraints.

Chen et al (1996) proposed a simulated annealing method to solve the weak bus oriented reactive power planning for system security. The algorithm identifies the weak buses and selects those buses for installing new reactive power sources to enhance system security. The main idea of this paper was that the voltage instability will occur at the weakest bus and needs new reactive power sources needs to be installed at those buses.

Chiang, H.D. and R.J.Jumeau (1995) proposed a performance index that provides a direct relationship between its value and the load demand that the system can withstand before voltage collapse.
Crisan, O. and M.Liu (1994) proposed a voltage stability index on the basis of an improved sensitivity model. The improved sensitivity approach includes the physical constraints on the power system, especially makes the model pertinent to the actual system conditions.

Deeb, N.I (1993) presented a novel decomposition based algorithm to solve RPP problem in large scale multi area power system by the application of the bender decomposition method.

Delfanti et al (2000) presented, a procedure to solve the capacitor placement problem, A MILP and generic algorithm were used to solve the problem. The objective was to determine the minimum investment required to satisfy suitable reactive constraints.

Gomez (1991) proposed a two level decomposition technique for VAR planning in electric power system. New VAR sources are modeled on discrete variables and the operations and investment cost were represented in detail in this paper.

Granville (1988) proposed methodology represents multiple load levels, multiple contingencies calculate the trade-off between investment cost and supply reliability and select the co-ordinate modes for VAR source planning.

Grudinin, N (1998) has proposed a bi-criterion reactive power optimization model that represents compromise between economical and security objective functions and the optimization problem are solved by quadratic programming.

Gubina, F. and B.Strmenik (1995) presented a ‘phasor concept’ of voltage collapse determination. The main idea proposed is that the voltage phasors contain enough information to detect the voltage stability margin.

Hong, Y.Y (1990) presented and integrated methodology for long term VAR planning. The time (years), the location and amount of VAR planning were determined by the integration on Optimum Power Flow (OPF) with the generalized render decomposition.

Iba,K (1998) proposed a successive linear programming method to solve reactive power planning problem. This method utilizes precisely calculated linear sensitivities including active power and voltage phase angle in the formulation.

Kessel, P. and H.Glavitsch (1996) presented a paper on “Estimating the voltage stability of a power system”. This paper suggests, voltage stability index (L-Index) based in normal load flow solution for on-line applications varies from 0 (no load of system) to 1(voltage
collapse). The bus with highest L-index value indicates the weak bus in the system and hence this method helps in identifying the weak areas in the system needing critical reactive power support.

**Lima et al (2003)** presented mixed integer linear programming (MILP) to conduct a preliminary design study on the combinational optimal placement of thyristor controlled phase shifter transformers (TCPSTs) in large-scale power systems.

**Lin X et al (2003)** presented a methodology for reactive power dispatch with consideration of the voltage stability problem. It solves both voltage stability and minimum reactive cost requirements in one unified optimization model.

**Lof, P.A (1994)** presented a fast method to calculate minimum singular value of the power flow Jacobian and modified power flow Jacobian matrices as a static voltage stability index, including the distance between the studied operating point and steady state voltage stability limit. The magnitude of the MSV is a measure of the proximity of the system to the steady state voltage stability limit.

**Lof, P.A (1995)** presented a paper on “Voltage stability indices for stressed power systems”. This paper presents and discusses the use of static voltage stability indices based on a singular value decomposition of the power flow Jacobian matrix and matrices divided from the Jacobian matrix. The indices based on these matrices are useful for the system analyst in planning and operations planning. It is shown that such indices, together with the singular vectors contain substantial and important information about the proximity to voltage instability point of view.

**Lof, P.A (1992)** presented and studies a static model for synchronous generators with the voltage dependent reactive power limits. The influence of voltage dependent reactive power limits is composed with fixed limits, by the use of minimum singular value of power flow Jacobian matrix and related sub matrices as indicators of the static voltage limit.

**Lobato, E et al (2001)** presented a mixed-integer linear programming optimal power flow and minimizing transmission losses and generator reactive outputs.

**Mantovani (1996)** has proposed LP and MILP to solve the reactive power planning problem. The problem was sub divided as investment sub problem and operation sub problem.
Musirin (2002) presented a paper on Estimating Maximum Load-ability for Weak Bus Identification using Fast Voltage Stability Index (FVSI). This paper demonstrates the use of line stability index termed as fast voltage stability index in order to determine the maximum load-ability in a power system. The bus that is ranked highest is identified as the weakest bus since it can withstand a small amount of load before causing voltage collapse. It involves the experimental procedure of Voltage stability analysis and evaluation of line stability index based on the load variation. The point at which FVSI close to unity indicates the maximum possible connected load termed as maximum load-ability at the point of bifurcations.

Obadina (1989) presented a method identifying dispensed reactive power (VAR) supply that will enhance power systems pre and post contingency voltage security subject to technical and economic constraints. The problem is formulated in two stages. The first stage involves a nonlinear optimization problem which minimizes the amount of reactive supply. The second stage employs a mixed integer linear program which optimized the number of coordinate buses for VAR support.


Vaahedi,E (2001) presented traditionally in optimal VAR planning; the feasible operation has been translated as observing voltage profile criteria ensuring that the system voltage profile is acceptable for system normal and post contingency condition.

Venkatesh(1999) proposed the nonlinear programming problem of ORPP has been solved in the successive objective fuzzy linear programming. ORPP problem has the objectives of optimally siting and sizing new capacitors at prospective location such that the transmission loss is minimal, acceptable voltage profile is obtained and the voltage stability is improved.

Venkatrama Ajjarapu (1978) proposed a method of determining the minimum amount of shunt reactive power (VAR) support which indirectly maximizes the real power transfer of voltage collapse occurs. Using a relaxation strategy that operates on a predicts corrector/optimization scheme, a voltage stability index that serves as an indirect measure to the closeness of reaching the steady state voltage stability limit has presented.
Venkatramana (1994) proposed a systematic approval to decide the location, size and number of reactive power devices required in a power system. Parametric linear programming is applied to solve the reactive power allocation problem.

The mathematical programming based methods suffer from the following limitations. They rely on convexity to find the global minima. The LP results may not represent the optimal solution to inherently nonlinear objective functions of the one used for the reactive power planning problem. The conventional method in solving a RPP problem is to approximate the set of control variables by continuous variables, and then the problem becomes an ordinary nonlinear programming problem.

After the continuous problem is solved, its solution is approximated to the closest discrete value. In practical applications, this approach usually leads to sub optimal solution that may be far from the global optimum. These traditional techniques also suffer from bad starting points and frequently converge to local minimum or even diverge. These techniques have severe limitation in handling nonlinear, discontinuous functions and constraints, and function having multiple minima.

2.3.2 Artificial Intelligence Techniques

Artificial intelligence (AI) techniques, practically expert systems have been utilized for solving reactive power planning problems. This approach consists of “If-then” based production rules. The construction of such rules requires extensive help from skilled knowledge engineers and also while using fuzzy based techniques the crisp modeling on variables may result in an infeasible solution to the optimization process cannot identify the optimal solution for the given operating constraints.

Abdul-Rahman, K.H (1995) presented an artificial (AI) approach to the optimal reactive power (VAR) control problem. The artificial overall network (ANN) is enhanced by fuzzy it is used to determine the memberships of control variables to the given load values.

Azmy, A.M (2006) presented a solution for the reactive power planning problem using genetic algorithm. This paper the candidate buses for reactive power insertion and determined. Admittance model for series compensators, phase shifter and unified power flow algorithm is presented to solve the problem that the standard Particle swarms.
Bhattacharyya (2007) used mixed heuristic and evolutionary technique for solving the require power problem. Here all variables were treated as control variables for reactive power planning. Heuristic method is used for installation of capacitors on weak bus and evolutionary programming approach is used for setting of transformer tap positions and reactive generations of the generator.

Bo Yany et al (2007) presented a survey of particle swarm optimization applications to solve power system optimization problems with optimal power flow, economic dispatch, reactive power dispatch, unit commitment, generation and transmission planning, maintenance scheduling, state estimation, model identification, load forecasting, control and others.

Chen, J (2012) has proposed a new reactive power planning based on system multi scenario operations. The main idea about this paper was that the new reactive power planning, the multi VAR sources are installed at those buses.

Chen, Y.L (1994) proposed a multi-objective optimization for reactive power planning. The objectives are active power loss cost reduction, minimization of the cost of investment VAR sources, system security margin enhancement and reduction of the voltage deviation of the system.

Ching-Fung, Lu (2013) proposed an evolutionary fuzzy lead-lag control approach for coordinated control of flexible AC transmission system (FACTS) devices in a multi-machine power system. The FACTS devices used are a thyristor-controlled series capacitor (TCSC) and a static VAR compensator (SVC), both of which are equipped with a fuzzy lead-lag controller to improve power system dynamic stability.

Ching Wei Chien (2011) proposed a novel algorithm to improve the performance of differential evolution. Mutation factor replaced traditional differential evolution algorithm used for constant factor increasing the performance. Condition based on variance is also presented. Considerable influence on secure and economic manipulation of power systems and Controller convergence condition based on variance is also presented.

Dong (2000) addressed the problem of achieving power system security, with competitive electricity market on reactive power planning. Genetic algorithm has been use for
solving the problem. The main outcome of the paper was planning the reactive power ancillary service market incorporating system security and minimizing the future risks.

**Durairaj, S(2009)** presented an improved genetic algorithm approach to solve the reactive power dispatch in power system incorporating thyristor controlled series capacitor (TCSC) device. The author use a binary coded GA with tournament selection, two point crossover and bit wise mutation is used to solve this mixed integer nonlinear optimization problem.

**Enqi Wu et al (2010)** proposed an adaptive particle swarm optimization (APSO) algorithm is presented to solve the problem that the standard particle swarm optimization (PSO) algorithm is easy to fall into a locally optimized point, where inertia weight is nonlinearily net off by using population multicity information. Velocity mutation factor and position sale factor are both proposed. The APSO algorithm thus improves its solubility for global optimization to avoid effectively the precocious convergence.

### 2.3.3 Evolutionary computation techniques


**Geng Huan Tong et al (2009)** proposed this paper presents an algorithm for solving reactive power optimization problem with the application of Evolution Strategy (ES) with stochastic category. In order to superiors improved the interpreter performance and practicality, the coding prescript for integer data of transformer tap position is designed deliberately and the self-adaptive optimization termination.

**Gerbex, S et al (2001)** presented a genetic algorithm to optimally locate multi type FACTs devices in power system. The system load-ability is used as a measure of power system performance. The optimization was performed on three parameters: the location of the devices, their type and their values.

**Gopalakrishanan (2004)** proposed a hybrid evolutionary programming method to solve RPP problem. The proposed technique was differing from the conventional EP solution by using the EP as a base level search towards the optimal region with limited computing time.
Subsequently a local search method of optimization by direct search with systematic reduction of the size of the search region.

Hamouz, AI et al (2007) proposed the applicability of the particle Swarm optimization algorithm to the optimal reactive power planning problem. The problem was composed into the real power and reactive power optimization sub problems. The real power P interpreter skeletonizes the operation cost by adjusting P generation, while Q optimization adjusts the transformer tap settings. The real power P and reactive power Q sub-problems were each optimized by the PSO in an iterative manner until the global minimum was obtained including the arrangement, maintenance scheduling, state estimation, model identity and load.

Hassan, M.O (2009) presented steady-state modeling of Static VAR Compensator (SVC) and Thyristor Controlled Series Compensator (TCSC) for power flow studies has been represented and discussed in details. Firing angle model for SVC was proposed to control the voltage at which it is connected. In same manner firing angle model for TCSC is used to control active power flow of the line to which TCSC is installed. The proposed models take firing angle as state variable in power flow formulation.

Homing Liu (2008) proposed algorithm can produce a good initial solution for Tabu Search (TS) because of the powerful global search ability of Ordinal Optimization (OO), and the convergence speed of TS can be promoted largely. The optimization process of the mathematical model consists of two steps, the first are to obtain a good initial solution for TS via OO, and the second is to find the global optimal solution using TS. Finally, a case study is conducted on a 28-bus distribution system.

Iba, K (1994) presented a new approach to the reactive power allocation planning. The GA based method utilizes unique intentional operators namely inter breeding and gene-recombination to solve the reactive power optimization problem.

Lai (1996) proposed an evolutionary programming method to solve the reactive power planning problem and it is compared with nonlinear programming method. The results obtained by using conventional gradient based optimization method and Boyden’s method are presented to show that the EP method was better for power system planning.

Lee (1998) has presented a comparative study of evolutionary programming, evolutionary strategy, Genetic algorithm and linear programming in solving the RPP problem.
The ORPP problem is decomposed into P and Q optimization modules, and each module is optimized by the evolutionary algorithm in an intensive manner to obtain the global optimal solution.

Lee (1995) proposed a linear programming and simple genetic algorithm to solve the reactive power planning problem. The propose VAR planning approach was in the form of a two level hierarchy. In the first level the SGA is used to select the location and amount of reactive power sources to be installed in the system. This selection is passed on the operation optimization sub problem in the second level in order to solve the operational planning problem.

Lima,F (2003) presented the use of advances in mixed integer linear programming (MILP) to conduct a preliminary design study on the combinatorial optimal placement of thyristor controlled phase shifter transformers (TCPSTs) in large-scale power systems. The procedure finds the number, network location, and settings of phase shifters that maximize system load-ability under the DC load flow model, subject to limits on the installation investment.

Liu.JWO.WA (2011) proposed hybrid expert system and simulated annealing (ESSA) approach to optimal reactive power planning problem. To achieve system maximum security and minimum cost in operation, reactive power planning is posed as a multi-objective optimization problem. Fuzzy satisfying method is introduced in this paper for the development of ESSA algorithm.

Liu Zifa et al (1998) proposed to deal with reactive power interpreter case, an Adaptive Niche Particle Swarm Optimization algorithm (ANPSO) is presented. Differential Evolution algorithm (DE) is easy to use and has the advantages of strong solidity, but its capacity is limited and maybe to fall into local optimum because the population loss of diversity after several generations. ANDE familiarized niche-sharing mechanisms to change the individual values and accelerates to eliminate individuals which have inferior rate. Nicking radius can also be net off adaptively on the basis of the relative distance between individuals which reflect the concentricity of settlement. Using the above method, algorithm’s global searching ability is developed.

Mancer.M (2012) proposed multi-objective optimal reactive power flow considering FACTS technology. The author presents a new variant of particle swarm algorithm with time
varying acceleration coefficients to solve multi-objective optimal reactive power flow. Optimization (PSO) algorithm is easy to fall into a locally optimized point.

Mehdi Eghbal (2008) presented a new approach to treat reactive power (VAR) planning problem using multi-objective evolutionary algorithms. Strength Pareto Evolutionary Algorithm (SPEA) and Multi-Objective Particle Swarm Optimization (MOPSO) approaches have been developed for minimizing the total cost Multi-objective teaching-learning-based optimization algorithm, for solving the optimal mutation factor and position sale factor are both proposed.

Nayak, M.R. et al (2012) proposed this paper non-domination based sorting multi-objective teaching-learning-based optimization algorithm, for solving the optimal power flow (OPF) case. The OPF case is a nonlinear constrained multi-objective interpreter case where the fuel cost, Transmission impairment and L-index are to be skeleton zed. Since the problem is deporting as a true multi-objective interpreter case, different trade-off settlement are provided. The judgment constructor has a choice to choose a solution among the asunder trade-off solutions provided in the pareto optimal front.

Peifeng Wu et al (2013) proposed the reactive power interpreter problem has a performance and practicality, the coding prescript for integer data of transformer tap position is designed deliberately and the self-adaptive optimization termination power flow (OPF) case. The OPF case is a nonlinear constrained multi-objective power system, Single sensitivity criterion for a given load if defined.

QH, WV (1995) was concerned with application of evaluating programming (EP) to optimal reactive power dispatch and voltage control of power systems. The proposed method was evaluated in IEEE 30-bus system.

Radman,G (2007) discussed power flow calculation of power system with multiple flexible AC transmission system (FACTS controller) by modifying and adding new entries in Jacobian equation with no FACTS controller and considered three major FACTS controllers STATCOM, SSSC and UPFC

Ramesh (2012) used Strategy (ES) with stochastic category, in order to improve the interpreter Strength Pareto evolutionary algorithm (SPEA) to address reactive power compensation in power system as a multi-objective problem was presented in this paper; reactive
The compensation problem was treated as multi-objective optimization problem with three conflicting objective functions. They are investment in reactive compensation devices, the active power production and voltage security.

Refacy (1995) has presented fuzzy based reactive power and voltage control in distribution system. The objective is to find the combination of main transformer load tap changer (LTC) position and capacitors on/off switching operation.

Salhi, A (2012) presented reactive power planning for enhancement of power system static voltage stability. On dominated sorting genetic algorithm used to minimize the active total loss and improve the voltage profile using Static Voltage Compensator (SVC).

Samir sayah (2008) has presented and efficient Modified Differential Evolution (MDE) algorithm for solving optimal power flow. The author made modification in mutation rule is suggested to the original DE algorithm solving reactive power optimization problem through the application of Evolution.

Santoso,N.I et al (1990) presented an expert system using 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. It has been concluded that the method requires much less computation time if compared with that for an optimization process.

Saravananan,M et al (2007) presented the application of Particle Swarm Optimization (PSO) technique to find the optimal location of flexible AC transmission system (FACTS) devices with minimum cost of installation of FACTS devices and to improve system load-ability (SL). Three types of FACTS devices, thyristor controlled series compensator (TCSC), static VAR compensator (SVC) and unified power flow controller (UPFC) have been considered.

Silas Stephen (2012) proposed fuzzy based stochastic algorithms for solving multi-objective reactive power optimization problem including FACTS devices. The author compared the effectiveness of proposed algorithm with evolutionary programming (EP), tabu search (TS) and particle swarm optimization (PSO).

security constrained optimal power flow results obtained using EP have been reported better than those obtained using conventional security constrained optimal power flow.

Suganthan, P (2010) presented a survey of differential evolution. The author presents a details review of the basic concepts of DE and a survey of major variants. It’s application to multi-objective, constrained, large scale, and uncertain optimization problem.

Tea Robic (2005) has presented differential evolution (DE) optimization application. Differential evolution combines the advantages of DE with mechanism a Pareto based ranking and state of the art evolutionary algorithm were discussed.

Thomas (1995) has developed a computer program SCORPION, which was used to plan investments in reactive compensation. This determines a near optimal pattern of new reactive sources required for voltage constraints to be satisfied in a number of system states.

Urdaneta(1999) proposed a modified genetic algorithm at an upper stage and successive linear program of lower stage for the solution of optimal allocation of reactive power sources problem. The optimization level was divided into sub problems. In the first level the generic algorithm was used to select the location of the new reactive power sources. This selection was passed on to the second level in order to select the amount of reactive power sources to be installed at each location by successive linear programming. Voltage source in series with impedance and proposed firing angle model for TCSC, Newton-Raphson method algorithm was implemented to solve power flow equation in the presence of STATCOM and TCSC. The algorithm developed shows excellent convergence characteristics.

Waxing sheng (2013) presented a distribution generation (DG) multi-objective optimization method based on an improved Pareto evolutionary algorithm is investigated. The improved Pareto evolutionary algorithm, which introduces a penalty factor in the objective function constraints, uses an adaptive crossover and a mutation operator in the evolutionary process and combines a simulated annealing.

Wen Zhang (2002) has proposed the theory of decomposition and coordination with improved Tabu search technique to reactive power planning in power systems. Based on theory of decomposition and coordination, the complex problem was decomposed into several sub problems with different load condition.
Wong (2005) proposed a relatively new population based optimization technical, differential evolution has been increasing probability distribution function comparing conventional evolutionary algorithm.

Ya chinclang (2013) proposed and installation of flexible AC transmission system (FACTS) in existing transmission network transmission system load margin improvement. The author formulated as a multi-objective optimization problem. The proposed method is validated on the IEEE 24 bus reliability test system (RTS) and a practical power system.

Yong Wang (2012) paper proposes an improved version of the CW method, called CMODE, which combines multi-objective optimization with differential evolution to deal with constrained optimization problems. Like its predecessor CW, the comparison of individual’s in CMODE is also based on multi-objective optimization.

Yong Wang (2005) proposed constraint optimization evolutionary based Multi objective optimization algorithm. Here feasible solutions has replaced by multi-objective optimization.

Yosionhikazu Fukuyama (2005) has proposed reactive power allocation problem as a mixed integer nonlinear programming problem dealing with both continuous and discrete variables. Four different particle swarm optimization techniques were presented to solve the reactive power allocation problem.

Yurong Wang (2011) proposed a new approach for modeling and solving VAR planning problem taking into account the static voltage stability constraint. First, the fuzzy clustering method is employed to select new candidate VAR source locations. Then, modified Gray code is proposed and used to represent a series of non-uniform VAR capacity intervals at different candidate buses.

Zhang Yang (2007) discussed new challenges to the problem of reactive power planning in electric supply industry. A novel method for reactive power planning based on chance constraint programming was presented.

From the above literature review, it is observed that most of the previous papers have not considered the combining multi-objective optimization with differential evolution for reactive power planning. For better improvement of voltage stability and reduction of real power cost an
improved differential evolution using FACTS controllers are not considered. This thesis presents an improved differential evolution for reactive power planning considering FACTS controllers.

The following issues are addressed in developing an improved differential evolution to reactive power planning using FACTS controllers.

a) Representation of solution: in the conventional methods to solve reactive power problem, the solution variables are presented as a continuous one. But in practical, those variables are discrete in nature. Such as transformer tap setting for multi-objective optimization.

b) Evolution of the solution: the improved differential evolution to load flow for the chromosome structure is defined in which and transformer tap setting. The control variables are self-constrained to handle inequality constraints of state variables including slack bus real and reactive power load bus voltage magnitudes, fitness function is considered in the problem.

2.4 SUMMARY

In this chapter, a detailed literature review of reactive power planning problem has been presented. The limitation of conventional optimization methods has been outlined. The potential for the application of improved differential evolution algorithm using multi-objective optimization to solve reactive power planning using FACTS Devices has been presented.