Review on Optimal Reactive Power Dispatch by optimization Approaches

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Abstract- Today‟s power system becomes more complex interconnected system due to alarming increase in load demand and dynamic load pattern which affect severely on transmission lines. They are operating either overloaded or under loaded. The uneven load distribution affects voltage profile and makes system voltage security vulnerable to the fault. It becomes difficult to maintain power system security and reliability. Conventional approach of add new transmission lines in the system and build new power generation facilities is bound with certain factors such as technical and economical bounds. So the best and necessary solution left is to make optimal use of existing generation and transmission network. GENERATOR controllers are the best and effective alternative for power system performance improvement like voltage security, transfer capability and reduction in reactive losses etc. instead of making complex new transmission corridor. These devices can be connected in series, shunt, series-series and series-shunt. It is important to decide GENERATOR devices type according to the purpose of need. For voltage control at the point, shunt controllers are desirable and power flow in the line can be controlled through series controllers. In experiment analysis of two bus system IEEE30 these two bus system replace fact on effective place in case of congestion. After congestion increase of loss on different loads. In Generator placement improve the congestion and reduce loss

Keywords: *loss,radialbus,optimization,load,economic*

I. INTRODUCTION

1.1 Overview

Reactive power dispatch (RPD) units, also known as cogeneration or distributed generation, have played an increasingly important role in the utility industry. RPD units are used to provide electrical power as well as power power to the customers [1]. RPD plays an important role in utility industry. It is used to provide power as well as electrical power to customer. RPD is thermally more efficient with the use of fuel than electricity generation. In individual production of electricity energy has been rejected as waste power but in RPD this waste power had been used for some good purposes. RPD helps to reduce the emission of pollutant gaseous like SO_2, CO etc. about 13 to 18 %. To integrate the RPD system or to increase its economy economic dispatch is applied to RPD. Economic dispatched (ED) is the most important optimization problems in power system operation. To minimize the total generation cost is the main objective of the economic dispatch.

Various problems in Economic Dispatch:

- Economic dispatch with value point (EDVP)
- Multi-area Reactive Power Dispatch (MAED
- Companied economic-environmental dispatch. (CEED)
- Cubic cost function economic dispatch. (QCFED)

These are some problems occurred in ED. There are some algorithms used to resolve these problems:

- Real-coded Genetic Algorithms (RCGA)
- Particle Swarm Optimization (PSO)
- Differential Evolution (DE)
- Covariance Matrix Adapted Evolution Strategy (CMAES)

RPDED is a non-linear and non-convex problem which is very challenging task to resolve. Economic dispatch (ED) [2] is one of the important optimization problems in power system operation. Economic Dispatch allocates the load demand among the dedicated generators most economically while satisfying the physical and operational constraints in a single area.

The main objective of economic dispatch [3] is to minimize the total generation cost such that the demand and constraints are satisfied, that is, we have to optimally generate power generation. Different problems occurred in economic dispatch [4-5] which includes economic dispatch with valve point (EDVP) effects, multi-area Reactive Power Dispatch (MAED), companied economic-environmental dispatch (CEED), and cubic cost function economic dispatch (QCFED).Some researchers has do research to solve the problem of economic dispatch using various algorithms like the Real-coded Genetic Algorithm (RCGA), Particle Swarm Optimization (PSO), Differential Evolution (DE) and Covariance Matrix Adapted Evolution Strategy (CMAES) are considered.

In fig 1.1 show the Economic dispatch problem was solved by who describes a method used to solve the problem based on the separability of the objective function of the problem. In this technique, a two-level strategy was adopted which is lower and upper level. The lower level was used to solve the (ORPD) economic dispatch problems of the individual units for given power and power lambda’s, and the upper level updates the

lambda's by sensitivity coefficients. This process was repeated until the power and power demands are met. ORPD problems divided into two parts which are: the power dispatch; and the power dispatch. To solve this problem two-layer algorithm was used. The outer layer uses the Lagrangian relaxation technique to solve the power dispatch iteratively. In each iteration, the inner layer solved the power dispatch with the unit power capacities passed by the outer layer. The binding constraints of the power dispatch are fed back to the outer layer to move the RPD economic dispatch towards a global optimal solution.

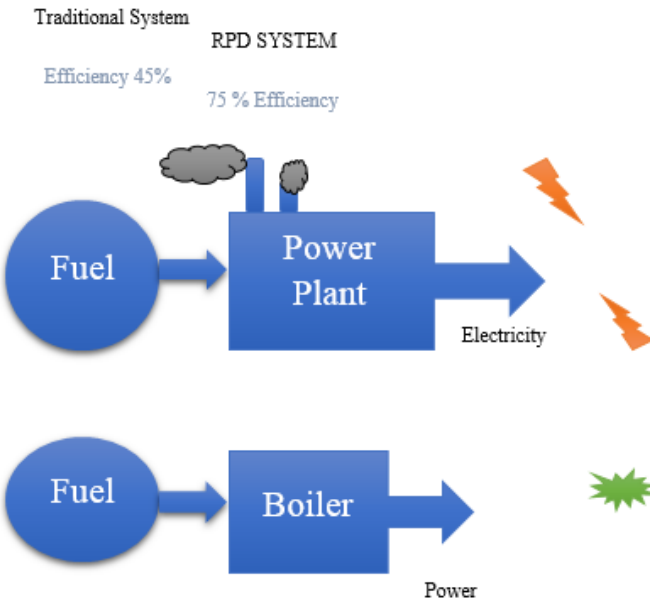

Figure 1.1 Combine Power and Power System[6]

There is sharp rise in energy demand which results increased pollution. Due to this, issues of energy conservation and green power gained much attention in 21st century [7]. The conversion of primary fossil fuels, such as coal and gas, to electricity is a relatively inefficient process. Even the most modern combined cycle plants can only achieve efficiencies in between 50–60%. Most of the energy that is wasted in this conversion process is released to the environment as waste power. The principle of Reactive power dispatch (RPD), also known as cogeneration, is to recover and make beneficial use of this power, which raise the overall efficiency of the conversion process[8]. The very best RPD schemes can achieve fuel conversion efficiencies of the order of 90%. The energy saving potential as well as less greenhouse gas emission due to the wise use of cleaner fossil fuels burned in RPD units, like natural gas, give them advantage from conventional power systems. Cogeneration systems have now been extensively utilized by the industry. The industries with necessities of both power and power can supply its own demands with RPD systems. RPD systems can be constructed in urban areas and used as distributed electrical energy sources. To obtain the optimal utilization of RPD units, economic dispatch (ED) must be applied for more energy saving. The objective of economic dispatch is to schedule the outputs of the online generating units so that the fuel cost of generation can be minimized, while simultaneously satisfying all unit and system equality and inequality constraints. Some complications arise in RPD systems because the dispatch has to find the set points of power and power production with the minimum fuel cost such that both demands were matched, indeed, the RPD units should operate in a bounded power vs. power plane. In the past, a wide variety of evolutionary algorithms (EA"s) have been used to solve ED problems [9]. Non-linear optimization methods, such as dual and quadratic programming, and gradient descent approaches, such as Lagrangian relaxation, have been applied for solving the RPDED. However, these methods cannot handle non-convex fuel cost function of the generating units. The advent of stochastic search algorithms has provided alternative approaches for solving the RPDED problem [10]. Improved ant colony search algorithm, evolutionary programming (EP) [4], the genetic algorithm, the harmonic search algorithm, and multi-objective particle swarm optimization (PSO) have been successfully applied to solve the RPDED problem. Differential evolution (DE) , a relatively new member in the family of evolutionary algorithms, was first proposed throughout 1994–1996 by Storn and Price at Berkeley as a novel approach to numerical optimization[11]. It is a population-based method and generally considered to be a parallel stochastic direct search optimizer that is very simple yet powerful. The main advantage of DE is its capability for solving optimization problems that a require minimization process with non-linear and multi-modal objective functions. DE has been applied successfully to various fiORPDs of power system optimization. In this thesis work one of the most recent heuristic techniques In a genuine bee colony, a few assignments are performed by particular people[12]. These particular bees attempt to augment the nectar sum put away in the hive utilizing proficient division of work and self-association. The artificial bee colony (ABC) algorithm, proposed by Karaboga in 2005 for genuine parameter streamlining is a streamlined algorithm which re-enacts the forging conduct of a bee colony. The negligible model of swarm intelligent rummage choice in a bumble bee colony which the ABC algorithm mimics comprises of three sorts of bees: employed bees, onlooker bees and scout bees [13].

A simple and very reliable method. These are precisely the characteristics of ABC that make it attractive to solve Reactive power dispatch economic dispatch (RPDED) problems [15].

1.2 Motivation

In the present scenario due to interconnection of various types of electrical networks, the energy related crisis has been

increased to a large extent. The continuous price rise has made the system to be monitored, to reduce the cost of operation in relation to electric energy. The current electrical utility target is to provide the electrical power in a very reliable manner possibly with low cost [16]. The storage of electrical energy is very difficult, but it can be generated form the sources available such as Renewable energy sources or conventional resources. Transmission system is generally used for delivery of power in bulk amount for a considerable amount of distance whereas the distribution system is used for delivery of local power. Now a days, there are many energy sources such as oil or gas, coal, water, wind power, solar energy, etc[17 18]. The choice of energy resource type must be taken on the basis of economic expenditure (first preference), then other type of conditions are kept in mind like the Technical and Geographical conditions. In case of generating units, Reactive Power Dispatch is considered as one of the very few problems in the operation of Power System. The new wave of implementing more amount of renewable energy sources makes such a problem even more significant now these days [19]. The main goal of problem related to Reactive Power Dispatch is to define the cost of production of each plant so that the total generation and transmission costs is possibly minimum for a particular amount of load. Some of the factors must be taken into account like the generating characteristics of plant, fuel power rate, the fuel used, the transmission losses, water reserved for hydrothermal, etc.

II. RELATED WORK

P. S. Nagendra Rao et.al. [2006] This article shows another calculation for the arrangement of the combined heat and power economic dispatch issue, experienced in frameworks having basic cycle co-era units with quadratic cost functions. An unequivocal equation is created for registering the framework wide incremental costs relating to the ideal dispatch. The curiosity of the proposed dispatch methodology is that it maintains a strategic distance from the utilization of iterative inquiry plans for this critical stride. The technique is represented utilizing the experiments taken from the writing and in addition some new ones.

A. Vasebi et.al. [2007] This paper shows a harmony search (HS) algorithm to explain the joined warmth and power financial dispatch (CHPED) issue. The HS algorithm is an as of late created meta-heuristic algorithm, and has been extremely effective in a wide assortment of advancement issues. The technique is shown utilizing an experiment taken from the writing and in addition another one proposed by writers. Numerical comes about uncover that the proposed algorithm can discover better arrangements when contrasted with conventional methods and is an effective search algorithm for CHPED issue.

Immanuel Selvakumar et.al. [2007] This paper proposes another variant of the established particle swarm optimization (PSO), specifically, new PSO (NPSO), to illuminate non-convex economic dispatch issues. In the traditional PSO, the development of a particle is represented by three practices, to be specific, inertial, subjective, and social. The subjective conduct helps the particle to recollect its already went by best position. This paper proposes a split-up in the psychological conduct. That is, the particle is made to recall its most noticeably awful position too. This change makes a difference to investigate the search space adequately. Keeping in mind the end goal to well adventure the promising arrangement area, a basic local random search (LRS) system is coordinated with NPSO. The resultant NPSO-LRS algorithm is extremely compelling in settling the non-convex economic dispatch issues. To approve the proposed NPSO-LRS technique, it is connected to three test frameworks having non-convex arrangement spaces, what's more, better outcomes are acquired when contrasted and past methodologies.

Hamid Reza Abdolmohammadi et.al. [2007] In this paper, a calculation in view of Benders decomposition (BD) is proposed to understand the economic dispatch (ED) issue for cogeneration frameworks. In the proposed technique, consolidated heat and power economic dispatch issue is deteriorated into an ace issue and subproblem. The subproblem produces the Benders cuts and ace issue utilizes them as another disparity limitation which is added to the past imperatives. The iterative procedure will proceed until upper and lower bounds of the target work ideal qualities are sufficiently close and a united ideal arrangement is found. Drinking sprees decomposition based approach can give a decent structure to consider the non-arched doable operation areas of cogeneration units proficiently. In this paper, a four-unit framework with two cogeneration units and a five-unit framework with three cogeneration units are dissected to display the viability of the proposed approach. In all cases, the arrangements got utilizing proposed calculation in light of Benders decomposition are superior to those acquired by different strategies.

Lingfeng Wang and Chanan Singh [2008] used the stochastic model for combined heat and power (CHP) dispatch which has been formulated first and then an improved PSO (particle swarm optimization) method has been developed to solve the economic CHP dispatch problem. The results for Stochastic and deterministic models on power dispatch has been analysed.

Nidul Sinha et.al. [2008] This paper explores into execution of Genetic Algorithms (GA) for fathoming combined heat and power dispatch (CHPD) problems in power frameworks. Distinctive calculations in various mixes of hybrid and change elements of GA are investigated and tried on an experiment of combined heat and power dispatch issue. The reenactment comes about demonstrate that all the drifting point GAs

(FPGA) perform superior to twofold GA in taking care of non-convex CHPD problems. Among the FPGAs, the execution of the FPGA with heuristic hybrid and multi-non uniform transformation is the best.

M Ristic et.al. [2008] An optimization model to break down ideal here and now operation plans for CHP frameworks was created and actualized. The model enhances the operation of the CHP framework in mix with a secondary boiler and heat storage. A technique to limit cost capacity was created and actualized. The optimization model was completely investigated and analysed with three reference cases. The execution of the optimization code showed a critical decrease in fuel costs. Such a CHP framework would be intended for greatest electricity to heat ratio and sized by the pinnacle warm demand. Showcase support considered for this situation expect a high level of market straightforwardness and openness.

Leandro dos Santos Coelho et.al. [2008]Particle swarm optimization (PSO) is a population-based stochastic algorithm driven by the reenactment of a social mental representation rather than the survival of the fittest person. Roused by the swarm insight and probabilities speculations, this work shows the utilization of consolidating of PSO, Gaussian probability distribution functions and additionally turbulent groupings. In this specific circumstance, this paper proposes enhanced PSO approaches for settling EDPs that considers nonlinear generator components, for example, incline rate constrains and restricted working zones in the power framework operation. The PSO and its variations are approved for two test frameworks comprising of 15 and 20 warm era units.

P. Subbaraj et al. [2009] used a SARGA (self-adaptive real-coded genetic algorithm) is implemented to solve the CHPED (combined heat and power economic dispatch) problem. The SARGA has been applied to solve CHPED problem with bounded feasible operating region that has large number of local minima. Simulated results show that the proposed method could find a solution towards the global optimum and have better solution quality and computation time.

Aiying Rong et.al. [2009] This paper addresses the unit commitment (UC) in multi-period combined heat and power (CHP) generation arranging under the deregulated power showcase. In CHP plants (units), era of heat and power takes after joint attributes, which suggests that it is hard to decide the relative cost productivity of the plants. It present in this paper the DRDP-RSC algorithm, which is a dynamic regrouping based dynamic programming (DP) algorithm in light of direct unwinding of the ON/OFF conditions of the units, consecutive commitment of units in little gatherings. Loose conditions of the plants are utilized to lessen the measurement of the UC issue and dynamic regrouping is utilized to enhance the arrangement quality. Numerical comes about in light of real-life data sets demonstrate that this algorithm is proficient and ideal or close ideal arrangements with little optimality hole are acquired.

J. S. Al-Sumait et al. [2010] PS optimization has been used to solve a variety of problems of power system ELD. Author applied this method to solve problems, including the EDVP effects, MAED, CEED, and QCFED. PS approach provides better optimal solution and simplicity of PS makes it more efficient. PS technique has been used to study wide range of optimization problem in the area of power system. The outcome obtained showed that for solving ELD problems PS method has an efficient solution.

Chao-Lung Chiang et.al. [2010] This paper shows a hybrid differential evolution with multiplier updating (HDE-MU) to settle the complex combined heat and power economic dispatch (CHPED) issues. Transmission misfortunes and valve-point impacts of regular warm generators are considered. The hybrid differential evolution (HDE) can effectively seek and effectively investigate arrangements. Multiplier updating (MU) is acquainted with abstain from twisting the augmented Lagrange function (ALF), which is embraced to oversee framework limitations of the CHPED issue. The proposed HDE-MU incorporates the HDE with the MU. A useful CHPED framework is utilized to show that the proposed calculation has the advantages of straight imposition; simplicity of usage; better viability than the past techniques, and the necessity for just a little population when connected to the CHPED operation.

Haiyan Lu et.al. [2010] This paper proposes a technique for incorporating a real-valued mutation (RVM) operator into the PSO algorithms, gone for upgrading worldwide inquiry ability. Three variations of PSO algorithms are considered. The resultant half breed PSO-RVM algorithms are tentatively explored alongside the PSO variations and a current PSO with Gaussian mutation utilizing six normal benchmark functions. It is fascinating to see that the viability of RVM fluctuates for various PSO variations as well as various types of functions. It has been found that one of the crossover algorithms, CBPSO-RVM, which is a joining of the PSO with the constriction factor and inertia weight (CBPSO) and the RVM operator, shows essentially better performance in the majority of the experiments contrasted with the other algorithms under thought. Furthermore, this algorithm is superior to the vast majority of the current algorithms utilized as a part of this review when connected to two handy ED issues with non-smooth cost work considering the multiple fuel type and/or valve-point stacking impacts.

Year of Publication	Author	Tittle	Source	Summary
2017	Feng, Zhi-Yong	Hybridization of harmony search with NORPDer-Mead algorithm for Reactive power dispatch economic dispatch problem	IEEE	In this paper, the author hybridized the two methods of optimization and use to solve the problem of RPDED. Harmonic Search and NORPDer-Mead algorithm s combined to solve the non-convex problem. The proposed method enhanced the effectiveness and also improves the robustness of the system. The overall performance of the system is better than the existing methods.
2017	Vögelin, Philipp	Heuristic approach for the economic optimisation of Reactive power dispatch (RPD) plants: Operating strategy, power storage and power	IEEE	presented a meta-heuristic algorithm which determines the most profitable settings within a given boundaries. The proposed approach is based on the mixed-integer linear programming. This approach is suitable for a large number of plants and resolves the full year data of electricity. This algorithm is 34 times faster than MILP solver. This algorithm solves the RPD problem very effectively
2016	Beigvand, Soheil Derafshi, Hamdi Abdi, and Massimo La Scala	Reactive power dispatch economic dispatch problem using gravitational search algorithm.	*Electric Power Systems Research*	proposed an optimization algorithm called as gravitational search algorithm to solve the power and power economic dispatch problem. This approach is completely based on the gravitational law and the law of particles motion. GSA algorithm works effectively on the valve point loading effect and transmission losses. The result of the proposed approach is compared with various algorithms and its give better results at low cost.
2016	Haghrah, A., M. Nazari-Heris, and B. Mohammadi-Ivatloo	Solving Reactive power dispatch economic dispatch problem using real coded genetic algorithm with improved Mühlenbein mutation	*Applied Thermal Engineering*	introduced the method of optimization using the genetic algorithm. In this method, mutation is implemented on the basic RCGA for speeding up and provides improvements in optimization. The author also introduced the cost and emission functions of three types of generating units, conventional thermal units that generate power only, RPD units that generate both power and power, and power-only units that generate power only
2016	Perea, E.	A novel optimization algorithm for efficient economic dispatch of Reactive power dispatch devices.	IEEE	in this paper, the author proposed a control algorithm to optimize the operating cost of one or a set of RPD unit. This algorithm minimizes the value of the target function. The series of weight that penalizes the violation of certain constraints include in the target function. The result of the paper shows that it is very cost effective. This experiment is also tested on the real building installation.
2015	Mellal, Mohamed Arezki, and Edward J. Williams	Cuckoo optimization algorithm with penalty function for Reactive power dispatch economic dispatch problem	IEEE	Proposed the cuckoo optimization algorithm to solve the problem of RPDED. This algorithm is used with penalty function and provides better optimization. The proposed method reduces the production cost performs well. The experiment result shows that it works very effectively when compared with the existing methods of the optimization.
2014	Adhvaryyu, Pradosh Kumar, Pranab Kumar Chattopadhyay, and Aniruddha Bhattacharjya	Application of bio-inspired krill herd algorithm to Reactive power dispatch economic dispatch	IEEE	algorithm is proposed in this paper which is a bio-inspired algorithm. This algorithm follows the herding behavior of krill's to find the global optimal solution. In this paper, the objective function is defined as the distance of each krill from the food. The simulation results of the proposed method are compared with PSO and some other methods. The comparison shows that KH method is better than other methods.

III. CONCLUSION

The power generating plant may be of any kind such as gas, nuclear, hydro, thermal, or any other type. Generating plants have distinct characteristics which provide different costs of generation at any load. Therefore, the plants require proper scheduling for minimum cost of operation optimally which becomes significantly important. As the cost characteristics of the issues for achieving the minimum amount of cost becomes a non-linear problem/issue [21]. The power generating units (PMUs) based Reactive Power Dispatch (ORPD) has always employed a significant position in the industry of electric power[22]. ORPD represents a computational process where

the required generation in total is distributed among the units of generation with the help of minimizing the selected criterion of cost, subject to load and operational constraints. For any kind of load condition specified, ORPD helps to determine the power output of each power plant along with each of the generating unit within that plant which will afterwards minimize the overall cost of fuel required to feed the load of the system [21] [23] [25] [26]. In the past decade, many of the researchers has made numerous efforts in solving the problems of ED, incorporated with distinct kinds of constraints through the several techniques of optimization like the traditional or conventional methods including base point, participation factor method, Newton method lambda iteration method, gradient method, Nonlinear programming (NLP), Mixed-Integer programming (MIP), Linear programming (LP) [3], Quadratic programming (QP) [27]. In gradient based and lambda iteration methods, the solution to ORPD is usually obtained by representing the cost function approximately for individual type of generators in terms of individual quadratic function. Such techniques needs an incremental fuel cost curves which are monotonically increasing and linear piecewise in order to find the optimal solution globally. For the generators with (non-monotonically) incremental cost curves, the conventional methods flattens or ignore the incremental cost curve out portions that are not monotonically or continuous increasing

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