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A Review on for Reactive Power Dispatch in Power Systems

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Abstract: Operation of the power grid with proper planning is an essential activity to improve the country's economy. The Optimal Reactive Power Dispatch (ORPD) plays a key role in ensuring safe , stable and optimum power system operations. ORPD is a dynamic, non-linear , non-convex, non - stationary and multi-model issue affecting both distinct and ongoing variables. thus solution involves various objective functions such as enhancing the voltage profile, decreasing energy loss, enhancing the system reliability and minimizing transmission costs. This paper makes an effort to explain the different concepts involved in the dispatch of reactive power and to introduce a particular work carried out by the numerous researchers in this field utilizing various strategies.

Keywords: *Power System, Optimal reactive power dispatch, Voltage stability, particle swarm optimization, differential evolutionary programming*

I.INTRODUCTION

Optimal Reactive Power Dispatch (ORPD) plays a key role in economical power system operation. The electric power system[1] draws full power from it. The device uses active power whereas reactive power flows in the power system. However, the reactive power serves a vital role in the regulation of voltage and the actual power transfer within the device. Therefore, the assessment of reactive power dispatch is important. ORPD's key goals are: reducing active power failures , optimizing tension profile[2], reducing transmission costs and enhancing voltage stability in the power devices [3].

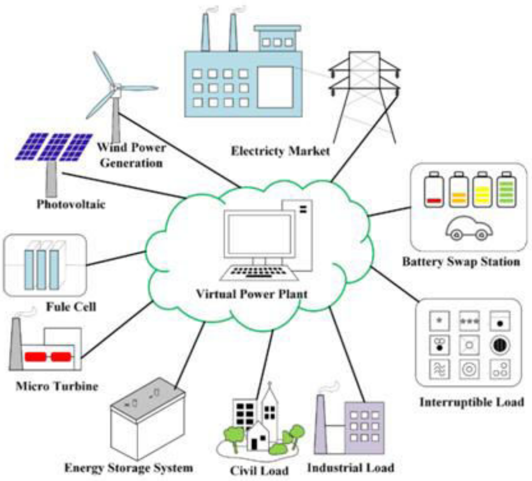

Fig. 1: Power dispatch distribution

II.REACTIVE POWER DISPATCH

The issue of Reactive Power Dispatch (RPD) has a considerable influence on the safe and economical operation of power devices . It is one of the most complicated problems, as it involves reducing the actual power failures in an electrical system[2]. The Optimal Reactive Power Dispatch (ORPD) is an issue of non-linear optimization, with several inconsistencies. It is a method that distributes reactive power generation to mitigate actual power transmission failures, holding all voltages within constraints while following a number of criteria equality and inequality. In today's operation of the power system, voltage stability is becoming a big issue which relies on the utilization and management of reactive power. Securing sufficient amount of reactive source of power in the network for safe and stable operation of the electrical power system becomes quite significant[4].

III.Mathematical Formulation Of Optimal Reactive Power Dispatch

ORPD issue can be represented as follows:

Minimise f(x,u)

s.t g(x,u)=0 ……………….. (eq. 1)

h(x,u)$\leq$ 0

where the function of f(x, u) is the objective function, g(x, u) = 0 is the equality constraint, h(x, u) d 0 is the inequality limit , x is the vector of dependent variables and u is the vector of control variables. The objective function to be reduced is the average transmission loss, P_{Loss} and the equality constraint is the power balanced equation of load flow, as [5]:

$f(x,u)=P_{loss}(x,u)=\sum_{L=1}^{NL} P_L$ ....(eq. 2)

$P_{Gi} - P_{Di} = V_i \sum_{j \in Ni} v_J (G_{ij} \cos \theta_{ij} + B_{ij} \sin \theta_{ij})$....(eq. 3)

$Q_{Gi} - Q_{Di} = V_i \sum_{j \in Ni} v_J (B_{ij} \cos \theta_{ij} + G_{ij} \sin \theta_{ij})$….(eq 4)

where P_L is the real power failure at line-L, N_L is the average of transmission lines, P_{Gi} is the real power generation at bus i, P_{Di} is the actual demand at bus i, Q_{Gi} is the reactive power generation at bus i, Q_{Di} is the reactive demand at bus i, Vi is the voltage magnitude of i^{th} bus, G_{ij} and B_{ij} are the conductance and susceptance of the transmission line i-j, and $ş_{ij}$ is the angle between of i-jth transmission line.

In term of operating constraints the inequality constraints can be expressed as follows:

Generator constraints: True and reactive electricity production and bus voltages are limited by their thresholds;

$P_{Gi}^{min} \leq P_{Gi} \leq P_{Gi}^{max}$ i=1,….,N_G ……..(eq. 5)

$Q_{Gi}^{min} \leq Q_{Gi} \leq Q_{Gi}^{max}$ i=1,….,N_G ……(eq.6)

$V_{Gi}^{min} \leq V_{Gi} \leq V_{Gi}^{max}$ i=1,….,N_G ……(eq.7)

where N_G is theamount of generators.

Transformer tap setting are bounded by their lower and upper limits, as follows:

$T_i^{min} \leq T_i \leq T_i^{max}$ i=1,….,N_T ……(eq.8)

where N_T is the of transformers.

Reactive compensators (Shunt VARs) are bounded by their limits as [6]:

$Q_{Ci}^{min} \leq Q_{Ci} \leq Q_{Ci}^{max}$ i=1,….,N_C ……(eq.8)

where N_C is the amount of the shunt compensators.

The positive effects involve reductions in the cost of fuel production[4], unloading of system equipment, enhanced security mechanism and enhanced power voltages.

Optimal issue of reactive power dispatch can be fixed [7] as a single objective optimization issue and multi-objective optimization issue.

- **Single Objective Optimization (SOO) Problem:** A single objective issue means that takes into account only one optimal solution at a time.Mathematical representation of SOO is represented as :

Min/maximization

Subjected to f(x)

$g_i(x) \leq 0$ where i=1,2,3……i

$h_j(x)= 0$ where k=1,2,3,…..j

- **Multi Objective Optimization (MOO) Problem:** Multi objective optimization problem is represents as :

Min/maximization

Subjected to f(x)=[f1(x),f2(x),f3(x)…..fk(x)}

$g_i(x) \leq 0$ where i=1,2,3……i

$h_j(x) = 0$ where k=1,2,3,….j

IV .LITERATURE SURVEY

Cabezas et al.,[8] In this research the elimination of active power losses was explored using the Particle Swarm Optimization (PSO) methodology via the optimal dispatch of reactive power and optimal voltage control. This work carried out using Matlab, and MATPOWER was used as a load flow solver engine. The product quality is verified with the 14-bar IEEE test power device reaching a loss reduction of 8.38%. The failure of the active power aligns from 13,393 to 12.27 MW after 100 iterations.

Garaske et al.,[9] The EORPD is presented in this paper as an expansion of OPRD issue. The implementation of three PSO variants for the EORPD is clarified, and the approach is extended to a large-scale generation & distribution grid model to optimise power transfer taking into account a number of operational degrees of freedom . The model gives alternatives which are feasible and effective. Extension and modifying the original PSO technique has shown the possibility for increase in quality of the outcomes and the computation time. Simulation setup demonstrates high potential for improvement in both optimization problem and PSO algorithm ability to adapt.

Liu et al.,[10] A semi-definite programming (SDP) method to fixing optimal RPR design is suggested in this paper. The suggested technique converts the problem into iterations, and every iteration is resolved by SDP as an optimal power flow issue. To demonstrate the feasibility of the approach suggested, IEEE 118 framework is set as the test case in three load situations. Outcomes show the efficacy and robustness of the suggested technique .

Mustaffa et al.,[11] This article suggests an inherent strengths of a developer/ named a moth-flame optimizer (MFO) to resolve the ORPD issue. The usefulness of MFO is evaluated with 25 control variables on the IEEE-30 bus service and the contrast with another recent techniques such as the grey wolf optimizer (GWO), ant-lion optimizer (ALO), and multi-verse optimizer (MVO) will also be discussed in this paper. Suggested MFO has proved to achieve the highest reduced reduction of transmission power (PLoss=2,8298 MW). It is also checked such that the largest proportion of loss can be minimised between other architectures checked. It is around 50.76 per cent decrease in losses which can have a significant effect on resolving ORPD issues in the power system.

Peng et al.,[12] This paper offers a realistic fresh strategy for the integration of PET-based AC / DC hybrid power delivery power grids with high-permeability distributed photovoltaics into multi-objective optimum scheduling analysis and cost analysis. Using PET and grid-connected photovoltaic converters together with C3 control mode decreases voltage deviation and line transmission power. The power failure and maintenance costs are further decreased and the performance of the power grid is the greatest in safety , reliability and economy.

Rashid et al.,[13] This article proposes a recent SI strategy, the Cuckoo Search Method in ORPD solving problems. CSA 's efficacy was tested utilizing IEEE-57 bus system. Results of the simulation revealed that CSA is stronger in terms of achieving the lowest power loss compared with other methods, and is stable and reliable.

Khan et al.,[14] In this study mathematical formula of variable speed is being applied on Matlab code a wind turbine with its existing methods. To boost DFIG's tracking response, a traditional controller is contrasted to the Relative, Integral, and Differential (PID) controller to provide optimum power output. Analysis of outcomes depict the robustness of PID controller as compares to conventional controller.

Nazmul et al.,[15] Two solution methods (PSO and Pattern Search Algorithm) are correctly merged in this paper for optimal reactive power dispatch for distribution networks consisting of wind and solar-PV generators. Two MATLAB and DIgSILENT Power Factory simulation systems are merged to more easily conduct simulation. The IEEE 39 bus system model was updated to illustrate the effect of the optimization. The numerical simulations clearly outlined the optimisation of all generators, namely solar and wind generators, for reactive electricity. It also discovered the optimal tap locations of the transmission lines changing under load.

Sagara et al.,[16] This paper describes a solution to enhance the voltage reliability of the power grid via transmission line's active and reactive power data as per the voltage stability index. Replacing a battery at the charging substation to deliver the right amount of active power and reactive power will increase the system's voltage stability as seen by simulations.

Suresh et al., [17] Gravitational search algorithm (GSA) was presented to solve the optimal issue of reactive power flow in a power system. This method helps to reduce power errors and maximize the power system's voltage profile. Even this algorithm increases the system 's economic functioning. The independent variables for optimizing the reactive power flow were transformer bus voltage magnitude, SVC controllers, and transformer tap settings. Gravitational proposed algorithm was a recently designed algorithm inspiration from nature for global optimisation. On the IEEE 30 bus test method, GSA-based method was invented, and the results contrasted with other algorithms, and superior values were achieved.

Tejaswini et al., [18] New meta-heuristic optimization method , named as e Cuckoo Search Algorithm, has been presented to fix optimal reactive power dispatch (ORPD). This paper responsible for processing to mitigate transmission losses and to concurrently boost the voltage profile within a power system. The optimum reactive power dispatch issue was addressed as a challenge of multi-objective optimization although meeting all security constraints. The assessment demonstrates the effectiveness of the cuckoo quest method and the benefit of solving ORPD issue. This method was illustrated on standard IEEE 30 bus test device, and the simulation results acquired were superior to the method for differential evolution.

Table 1:Comparsion table of Different techniques in Voltage Stability

S.NO	Objective function	method	Outcome
1.	Reduce Power Losses & Enhancement Of Voltage Stability[17]	Gravitational Search Method	Outcomes were compared with other techniques and found superior. results.
2.	Fuel Cost, Decrease Real Power Failures	Evolutionary Programming technique [19]	Checked and the findings achieved on IEEE-30 test problems were promising.
3.	Reduce Power Losses & Enhancement Of Voltage Profile[18]	Cuckoo Search method	Results were superior to differential evolution algorithm.
4.	Reduce Power Losses & Voltage Deviation[20]	Big Bang – Big Crunch (BB-BC) Algorithm	Exempt of a huge number of users and this method is simple to encode
5.	Reduce Power Losses & Improvement Of Voltage Profile	Optimization Toolbox Of Matlab[21]	Outcomes demonstrated that suggested method reduced the power losses.

V. CONCLUSION

Optimal power dispatch is a method of configuration to evaluate the schedule for energy systems to satisfy the generation capacity while fulfilling the system requirements. Typically it seeks to minimize the cost of distributed generators or the emission of pollutants. In this paper , different optimization strategies are examined to address the issue of reactive power optimization A comprehensive literature review on the issue of reactive power optimization .It highlighted the drawbacks of traditional optimization techniques. There was discussed the opportunity for applying the particle swarm optimization algorithm to solve the issue of reactive power optimization.

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