Reactive Power Dispatch Optimization Using PSO-MFO

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Abstract— In view of the nature of RERs and the hybrid method (PSO-MFO) proposed to interact with the optimal reactive power dispatch issue, this study addresses the ORPD problem. The primary aim of the issue of reactive power dispatch is to reduce the actual loss of power and regulate the bus voltages in the power grid. Power methods are generally used to produce and supply information systems that are required to absorb limited resources while maintaining better reliability and safety. The hybrid approach also reduce the deviation in the voltage level and provides the proper VAR compensation which enhances the current stage of the PN. The RPD conducted on the IEEE bus 30 by examining the various control variables or obtain the best promising results as compare to base approach.

Keywords: Power Losses, RES, Reactive Power Optimization, ORPD, PSO-MFO

I. INTRODUCTION

With the growing power demand, power systems face severe difficulties. Enhanced power demand raises the need to define effective active and reactive power control systems at low transmission losses and appropriate voltage profile levels. The answer to the ORPD issue is a critical activity that helps to ensure the stable and safe functioning of electricity networks. In scientific terms, the ORPD issue has many objective functions, like minimizing voltage drop, minimizing voltage deviation and improving the power quality margin[1]. The purpose of discovering the ORPD solution is to determine the optimal modification of the dependent variables that accomplish one or more of the optimization problem described while the independent variables are optimal. Limitations on organizational equity and discrimination are valued. These independent variables include voltage magnitude at bus generation, change of transistor tap, and shunt injected compensators for reactive power[2]. Operational restrictions include a set of constraints on equality and inequalities, including the formula of active and reactive power balance and limitations on inequality, like load and generator bus voltage limits, power flow constraints, reactive power generation or shunt reactive power compensation.

In the previous years, power generation and energy saving are becoming significant areas of concern. By consuming a large amount of fossil fuels, most electrical energy is produced. The scientific advance of renewable energy adapters is being motivated by the reduction of fossil energy sources and air pollution. Active and reactive forces for economic activity are governed by the penetration of renewable energies into electrical systems[3]. In this way, the problem of reactive power dispatch is considered a major concern, since it reflects the method of injecting reactive power into the grid for enhanced voltage stability under heavily charged circumstances. The scope of the issue stems from the existence of the decision variable involved in the performance of the system, since it reflects on the grid modules' various voltage control factors. The operational constraints describe a non-linear and non-convex issue with both discrete and continuous parameters, such as the transformer tap setting, shunt capacitor bank injection and DG reactive power output[4].

This paper is organized as follows. Section I provides a brief introduction into the reactive power issues. Section II provides a short description and the mathematical formulation of the ORPD problem and small intro for the PSO algorithm and MFO used in the study is further presented. Section III presented literature review. Section IV exposes the analysis of the obtained results, while Section V concludes the paper and provides suggestions for future studies.

II. ORPD PROBLEM FORMULATION

For both discrete and continuous dependent variable, the ORPD requires a great restricted objective function aimed at determining the optimal allocation of power flows in the electric grid to minimize active power failures and voltage deviations[8].

A. General Optimization Model

For an optimization model, the basic graphical formulation could be represented as follows:

$$\text{MIN } F(x,y) \quad (1)$$

Subject to:

$$e(x,y) = 0 \quad (2)$$

$$i(x,y) \;\; 0 \quad (3)$$

Here F is the parameter to be minimized, while e and I define the limitations of equality and inequality based on the issue's independent and dependent variables (x and y). For the ORPD issue, x is a matrix representing the reactive power output of the engines, the CB operational stage, and the configuration of the OLTC transformers. Hence, x could be described as:

$$X= [Q_{g,1}.....Q_g,N_g,N_{CB},^1,.......N_{CB},N_{cb},T_1,.......T_{NT}.,] \quad (4)$$

On the other side, the vector of response variable, y, contains the active power supplied by the slack bus, P_{slack}, the voltage of the bus, and the transmission potential of the rails.

$$Y= [Pslack, V1....VNb, I\ 1,.......INl] \quad (5)$$

B. Objective Function

In the objective function of the ORPD issue, two terms were taken into account: the total active power failures and the variations in bus voltage. The alpha coefficient has been integrated into the formula for a comprehensive study of the effect of the two objectives on the optimization method, as obeys:

$$F=F_1+\alpha F_2 \quad (6)$$

– Minimization of the total active power losses
– Minimization of the bus voltage deviation

The ORPD Problem Constraints

1) Equality constraints:
The ORPD issue equality constraints are described by the formulas of load flow. The backward-forward sweep approach was utilize in the analysis for load flow estimation on the basis of the particular qualities of distribution systems (such as high R/X ratio, radial or weakly meshed networks, and so on).

2) Inequality constraints
Voltage constraints: At every bus i the bus voltage magnitude is limited within a minimal and a max distance, as it represents the power distribution efficiency.

$$Vi^{min} Vi \quad Vi^{max}, \; i = 1 \ldots\ldots nb \tag{7}$$

Operational constraints of the generators, capacitors banks and tap-changing transformers: The limitations provide the distributed generators' reactive power output, the shunt capacitor banks' operational phase, and the tap settings of the converter.

$$Qg, i^{min} \quad Qg, i \quad Qg, i^{max} \tag{8}$$

$$NCB, i^{min} \quad NCB, i \quad NCB, i^{max} \tag{9}$$

$$T\,l^{min} \quad T\,l \quad T\,l^{max} \tag{10}$$

Branches transfer capacity: The current should be within its thermal limit across any distribution line, which could be described as:

$$|Il| \quad Ii^{max}, \; i = 1 \ldots\ldots nl \tag{11}$$

PSO Approach is a stochastic meta-heuristic theory adopted by Kennedy and Eberhart in 1995, based on the natural behaviour of fish schooling or bird flocks[5]. Although since, implementations of the approach have been used in a wide variety of engineering issues, namely power systems. The method employs of the creation of a particle population, characterized by random orientation, which travels in the objective function with random values of its velocity. Every direction is directed to these positions found during the scan, guided by both the best-known position of particle (Pbest) and the best-known position of all substances (gbest).

MFO is one of the ongoing SI calculations which was suggested by (Mirjalili,2015) [6]. The MFO technique was focused on the moths movement towards the flame. The moths are empowered to pass significant distances in SL through keeping up a similar point concerning moon light. This route strategy is called transfer orientation.

III. LITERATURE SURVEY

Sylvere M. et al.,(2020) In able to fix the ORPD problem, the chaotic bat algorithm (CBA) is used, taking account small, large and medium power devices. The ORPD plays a crucial role in the function and regulation of the power grid. The ORPD issue, containing both continuous and discrete independent variables, is calculated by solving integer nonlinear programming issue. In order to improve its global search capability, the CBA benefits from the incorporation of chaotic sequences into the regular BA. To discover the perfect settings of generator bus voltages, tap setting transformers and shunt reactive energy sources, the CBA is used. This analysis takes into account three objective features, like the avoidance of active power loss, total voltage deviations and the voltage profile index. For the regular IEEE 14-bus, IEEE 39 bus, IEEE 57-bus, IEEE 118-bus and IEEE 300-bus test devices, the reliability of the CBA methodology is illustrated. The outcomes provided by the CBA are contrasted with other accessible approaches in the literature. The simulation outcomes indicate the efficacy and reliability of the CBA in resolving the ORPD issue[7].

Sidea et al.,(2019) In this analysis, the ORPD issue was fixed based on existing innovations in the systems to enable the function of the distribution network. The reactive output of the generator, tap changer positions and the current shunt capacitors were included in the model dependent variables. In two parts, the research paper was constructs. The conclusions drawn represent the conservation of the bus voltage within the permissible limits to a significant decrease in active power losses, by the required assignment of reactive power generation in the electric grid[8].

Kaur et al.,(2016) To achieve the study objectives, an Efficient Reactive Power Dispatch based on PSO using Graph Theory has been suggested. Graph Theory has been used because in situations of fault isolation and identification, or in the event of excessive or inadequate demand, it will be very helpful to shed unbalanced nodes. Computational experiments have been done on the updated IEEE-14 Bus System to demonstrate the efficacy of the suggested approach[9].

Shaheen A.M et al. [2016] BSA is implemented to tackle the ORPD problem to restrict the force misfortunes or potentially enhance the VP leveled out and subordinate variable needs. The suggested BSA is implement to the IEEE standard 30-transport framework, and a genuine force framework at WD device as an aspect of the UE device. Recreation Outcomes demonstrated stronger capacity of the suggested BSA for tackling the ORPD issue[10].

P.Anbarasan et al.,(2017) Explains a recently matured Moth Flame optimization technique for meta-heuristics that has been effectively used to recognize the ORPD issue. By changing the reactive power limit variables like generator output voltages, controlling transformers and reactive power sources in 30 bus and 57 bus info, this optimization approach is carried out . This new meta heuristic Moth-flame method researched the active loss of power and produced good outcomes contrasted to other approaches (the same data). This method showed the set of iterations, the features of convergence, the optimization strategy for data processing and an effective approach for managing constraints. For potential studies in different fields, the suggested Moth-flame method is strongly endorsed for explaining complicated engineering optimization issues[11].

A. To contrast hybrid proposed (PSO- MFO) approach with existing efficient Hybrid Algorithm.

The proposed methodology consist of hybrid PSO-MFO approach which helps to minimize the overall energy transmission failures and make the entire energy system more economical. Power processes are highly systems used to generate and fed information, which are anticipated to ingest limited funds while ensuring greater quality and protection. Optimal reactive power source is a particular issue of optimal power that has a massive effect on the safe and economical voltage regulation. APL and load BVD is a serious problem in the power generation at high voltage levels which should be minimized. The aim of power deploying in an optimized way in energy systems is to minimize outage probability and to enhance the reliability by minimizing the voltage deviations of the connected load while rewarding a specific set of designed to operate and physical constraints.

IV. PROPOSED METHODOLOGY

A. Objectives

1) To study the reactive Power optimization for Power losses.
2) To implement the PSO-MFO approach to reduce power losses.

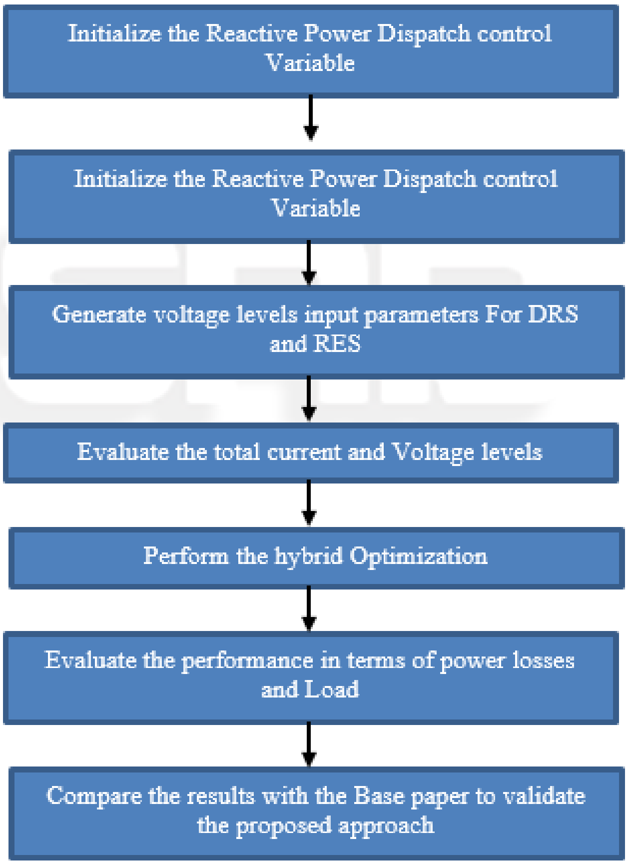

Fig. 1: Shows the Methodology Steps

V. RESULTS

Power consumption is an economical approach to reducing greenhouse gas emissions. (i) Power loss exists in a low voltage delivery method (ii) Substitution of traditional energy production by RES including wind and PV systems should be minimized. Researchers have concentrated on loss minimization and voltage regulations to address the problems that exist in distribution networks.

The efficacy of the suggested power-flow analytical methods is presented in this report by comparing various test cases. The first one comprises of a distributed network called Power Losses(MW). The purpose of this first distribution network is to validate the technique and examine its output in means of precision, productivity and convergence. A specific test case composed of an SVD(p.u) is then resolved by evaluating both the MATLAB and its specification through the use of the suggested protocol for power-flow analysis.

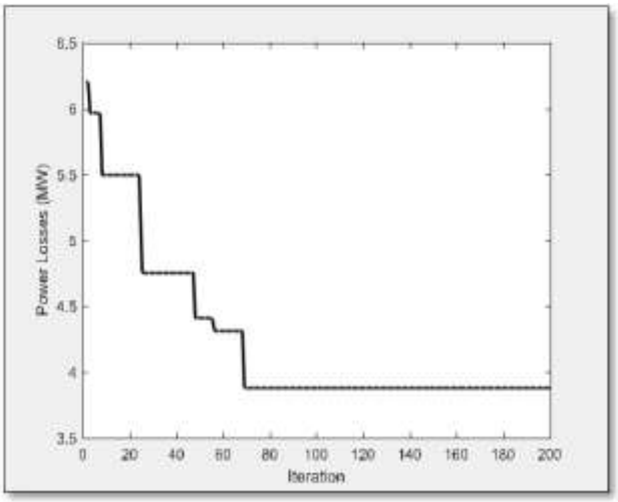

Fig. 2: Power Losses(MW) Versus Iteration

Variations in the power losses v/s the iteration amount for both load situations and for both discrete and continuous cases.

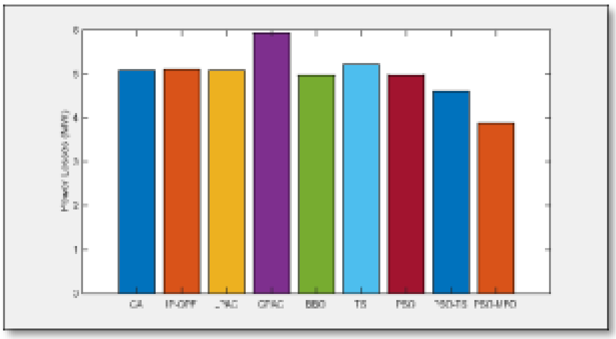

Fig. 3: Comparsion of Power Losses (MW) By Using Different Techniques

TECHNIQUE	POWER LOSSES
CA	5.0921
IP-OPF	5.1009
LPAC	5.0921
GPAC	5.923
BBO	4.965
TS	5.224
PSO	4.9819
PSO-TS	4.6034
PSO-MFO	3.8825

Table 1: Comparsion Table of Various Approaches for Power Losses (MW)

The comparison table of power loss is proposed various strategies to check minimum value analysis by performing distinct iterations to measure power losses (MW) and Figure 3 and Table 1 indicate that GPAC has resulted in more power losses and high power loss in various stages.

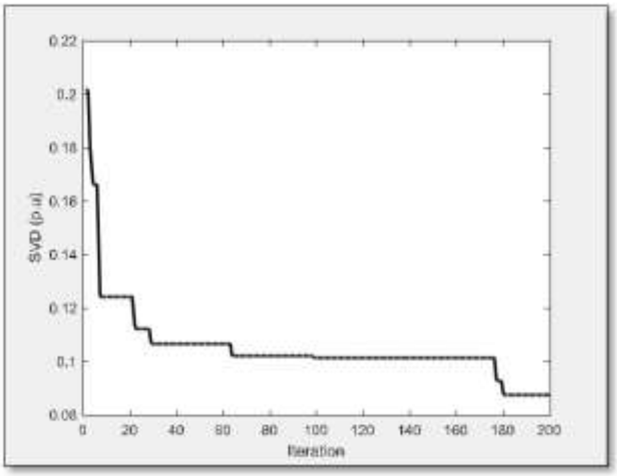

Fig. 4: Graph between SVD (p.u) and Iteration

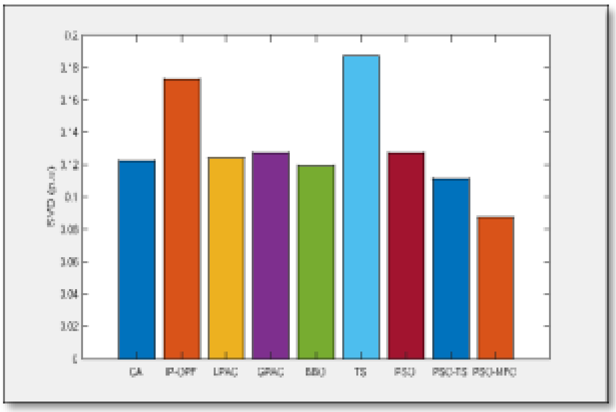

Fig. 5: Comparsion of SVD (p.u) By Using Different Techniques

Technique	SVD
CA	0.1225
IP-OPF	0.1733
LPAC	0.124
GPAC	0.1274
BBO	0.1194
TS	0.1874
PSO	0.1275
PSO-TS	0.1113
PSO-MFO	0.087616

Table 2: Comparsion Table of Various Approaches for SVD(p.u)

The comparison table of SVD(p.u) is proposed various strategies to check minimum value analysis by performing distinct iterations to measure SVD (p.u) and Figure 5 and Table 2 indicate that TS has resulted in more SVD(p.u) in various stages.

VI. Conclusion

A Hybrid PS)-MFO approach was developed and implemented in this article to solve the issue of ORPD for minor and major power systems. There has been consideration of single and multi-objective structures. Moreover, renewable energy resources, such as wind energy, offer huge rewards to critical load centers with ORPD. In the event of unresponsive buses, the findings were contrasted with those reported in the research. In order to mitigate distribution power losses and/or boost the voltage stability, the hybrid proposed PFO-MFO could solve single and multi-objective ORPD issues. The outcomes of the simulation have shown that the suggested approach contributes to a substantial reduced power losses at appropriate system voltage scales in the cases tested. The Future scope of proposed work are the fundamental goal of the optimum allocation of reactive power is to reduce system losses while preserving efficiency of the antenna. Using current infrastructure, like adjusting adapter bus current intensities or TC transformer layouts, the optimum distribution is accomplished. No extra investment is needed in this situation. In several electrical systems, static capacitors are often located at suitable areas to satisfy the defined operating conditions, Introduces to integrated configuration to address other more economical areas of load flow and function, It is hoped that the work introduced in this thesis will be helpful to power system engineers.

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