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A Novel Hybrid Gwo-Pso Optimization Technique for Optimal Reactive Power Dispatch Problem Solution

Mr. G Sudhagaran[1], Mr. S jaisiva[2]

[1] *UG Student, Department of EEE, IFET college of Engineering, Tamilnadu, India.*

[2] *Assistant Professor, Department of EEE, IFET college of Engineering, Tamilnadu, India.*

ABSTRACT
Power businesses require efficient and effective technologies to ensure that the desired electrical energy can be given at the lowest cost in the competitive environment. Environmental economic dispatch and real power economic dispatch are two examples of highly constrained optimization problems that are frequently generated by this setting.The practise of assigning generation levels to the producing units in the mix such that the system load can be fully and most economically supplied is known as economic dispatch (ED).The introduction of the valve point effect and various fuels in the actual ED issue models transforms the initial convex ED problem into a non-convex ED problem. Additionally, the power companies were under pressure from the public's growing awareness of the environmental pollution brought on by fossil fuel-powered power plants to reduce pollutions by fundamental ED renovation. It has resulted in the establishment of the Environmental Economic Dispatch (EED) problem, which has a number of goals including cost and emission. In the current situation, new optimization approaches are required to address more challenging optimization difficulties in the complex power business, which also includes power system limits and environmental issues.As a result, the main focus of this thesis has been on using recently presented and potent optimization methods to solve complex optimization problems connected to ED.

Keywords: *BLDC motor, PMBLDCM, Luo converter, ripple, PEC, Motor drive.*

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I. INTRODUCTION

In order to meet the expanding demands of its customers, the electric power business has experienced significant transformation throughout the entire world. The primary requirements of the consumers are an affordable and trustworthy supply of electricity. The best utilisation of the existing resources is required due to the rising demand for electricity and the diminishing energy sources. A key responsibility of a power system operator is to schedule the available generating resources to meet load demand in order to satisfy the financial needs of the consumers. Any power system that wants to return on its initial investment must operate economically. Fossil fuel conservation is a result of the rising cost of fossil fuels and the dwindling supply of these resources.The electric power business is under increased pressure in light of this situation to attain the highest possible fuel efficiency. In order to distribute generation among the committed units in a way that all imposed limitations are met while minimising operational fuel costs, a task known as "economic dispatch" (ED) is crucial in the management of the power system. According to Wood and Wollenberg, scheduling unit outputs more effectively can result in significant cost savings (1996). Therefore, the electric power business needs to give the economics of electric power generating itself more attention.

OPTIMAL ECONOMIC DISPATCH

When two or more generating units are committed to meet the load demand of the power system and their combined total generating capacity are more than the system demand, the necessity of the optimal economic dispatch becomes apparent. The goal of economic generator scheduling is to always provide the system with the best possible configuration of connected generators to meet load demand. This entails reducing fuel expenses, line losses, etc. Economic dispatch's primary objective is to plan the outputs of the operational fossil fuel producing units in order to fulfil system load demand at the lowest possible cost.The input-output characteristics curve (millions of Btu per hour against MW) of the generating units is necessary for the conventional ED. The units' incremental heat rates must follow a smooth, convex curve that increases monotonically. The monotonically increasing character demanded by the classic ED problem is not actually present in unit incremental heat rate curves. Power systems of today are extremely complicated and operate in an unpredictable manner. The primary goal of the traditional ED for electric power generation is to plan the committed producing unit outputs to meet the load demand at the lowest possible operating cost while satisfying the Wood and Wollenberg system equality and inequality criteria (1996).Limiting the emission of pollutants from fossil fuel-powered power plants is also becoming a crucial issue in the distribution of economic energy as a result of growing awareness of environmental contamination. Since conventional economic power dispatch simply takes into account minimising the overall fuel cost, it cannot satisfy the standards for environmental preservation. Electric power systems' multiobjective generation dispatch considers three economic and emission effect factors as conflicting objectives, necessitating a fair tradeoff between them in order to arrive at the best possible outcome.In order to dispatch the electric power while taking into account both economic and environmental issues, this formulates the Combined Economic Emission Dispatch (CEED) problem.To give the completeness for the ED formulation, a practical ED must take ramp rate constraints, banned operating zones, valve point effects, and numerous fuel options into account. The resulting ED is a very difficult non-convex optimization issue that cannot be resolved using conventional techniques.

II. LITERATURE REVIEW

Numerous studies on this ED issue have been published during the last 50 years. For the ED problem, numerous objective functions and solution strategies have been taken into consideration depending on the complexity under consideration. Only a few of the major literature's objectives and solution methods that have a direct bearing on the proposed task are taken into consideration. The following themes have been presented in a literature review.

CLASSICAL ECONOMIC DISPATCH

Below is a discussion of the numerous academic works that use fuel cost minimization's convex nature as a goal for the economic dispatch problem. In order to operate a power system economically, Lee et al. (1985) introduced a new method for optimal real and reactive power dispatch. The three main components of this methodology are optimal dispatch of four actual power, reactive power allocation, and load flow module. The gradient projection approach has been proposed in order to address this optimization issue. Chowdhury and Rahman have presented a general assessment of papers and reports covering many facets of the ED problem (1990).From 1977 through 1988 is the time frame covered. This survey provides a comprehensive picture of what is available, allowing researchers studying ED to pinpoint issues and look for solutions. In order to find the optimal shift in the ED problem related to contingency states or overload situations in power system operation and planning phases under various objectives such as economy, reliability, and environmental conditions, Farag et al. (1995) described a novel method and algorithm based on the linear programming techniques.Based on more than 150 papers over the past 20 years, a thorough overview of mathematical formulations and a general backdrop of techniques, analyses, and advancements in the subject of economic dispatch have been presented. Additionally, a database of the most popular test methods mentioned in the literature and used to evaluate various economic dispatch methodologies is offered.

NON-CONVEX ECONOMIC DISPATCH

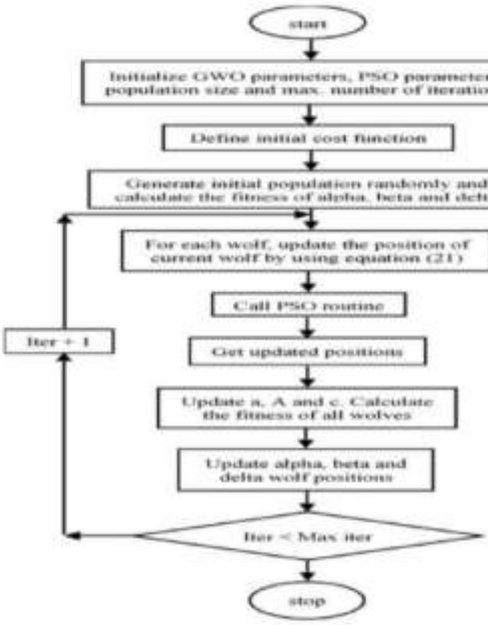
By include the valve point effect, various fuel options, and the fuel cost function, many earlier scholars have taken into account the non-convex form of objective functions. The following section discusses the literature on non-convex ED. By Walters and Sheble (1993), who show the multi-model solution space in the ED problem caused by the valve point effects, a recurrent rectified sinusoid contribution is introduced to the input-output equation in order to mimic the impacts of valve points. For the ED issue with piecewise quadratic cost function, Jayabarathi and Sadasivam (2000) provided a traditional evolutionary programming strategy, and the outcomes were compared with Hopfield neural network approach.Both Park et al. (2005) and Chiang (2005) have pioneered the modelling of actual ED problems by taking into account valve point effects and multiple fuels, both of which are present concurrently in real power systems. The ED problem was viewed as a non-convex optimization problem by Selvakumar and Thanushkodi (2007) by taking into account real-world operating constraints such the valve point effect, multiple fuels, forbidden operating zones, and generation ramp rate limits.The valve point effects have been taken into account by Coelho and Mariani (2008, 2010) and Amjady&Sharizadeh (2010) by including the sinusoidal function in the quadratic natured fuel cost function. By taking into account the valve point effect and various fuel alternatives, Bhattacharya and Chattopadhyay (2010) have established the convex and also a non convex ED issue. The ED issue was developed by Khamsawang and Jiriwibhakorn (2010) using three different fuel cost functions: ED with valve point effect, ED with valve point effect and various fuels, and ED with forbidden operation zones.

ENVIRONMENTAL CONSTRAINED ECONOMIC DISPATCH

This section presents research dealing with environmental restrictions as well as minimising fuel costs. Using contemporary probabilistic production costing techniques, Heslin and Hobbs (1989) provided a methodology to accurately assess fuel costs and emissions. The weighting approach is used to combine the several objectives into a single goal. A CEED problem was resolved by Dhillon et al. (1993) using a stochastic technique that accounts for uncertainty in the system cost and nature of load demand. The multi-objective ED problem's non-inferior solutions are found using a weighted min-max technique.7 An effective emission constrained dispatch method that reduces operational costs while simultaneously satisfying emission limits has been put forth by Ramanathan (1994). Two strategies are suggested in this paper. In the first approach, an effective mechanism is created to incorporate emission limits into the common classical ED issue and to quickly arrive to Kuhn-Tucker conditions. The Kuhn-Tucker criteria are reached using the second method, which uses partial closed form solutions. Talaq et al. provide an overview of the work done in the field of Environmental Economic Dispatch (EED) (1994). The summary includes a number of methods designed to lower atmospheric emissions caused by the production of electric power.Lamont and Obessis (1995) have reemphasized the importance of emission dispatching techniques and given a set of dispatching algorithms together with solution algorithms based on the 1990 modifications to the Clean Air Act. Lamont and Obessis (1995) have suggested a method to reduce overall operating expenses and to calculate the SO2 emission allowance as outlined by the Clean Air Act amendments of 1990. It also introduced a novel emission dispatch solution algorithm that reduces the generating units with the highest incremental emission to incremental cost ratio in order to get a minimal cost solution. An integrated methodology for modelling and assessing the financial effects of environmental dispatching and fuel switching has been proposed by Srinivasan and Tettamanzi (1997).

PROPOSED SYSTEM

A swarm-based metaheuristic optimization technique is what the PSO is categorised as [41]. A population-based exploration approach is used in PSO to locate the global optimization. The actions of the birds serve as its inspiration [42]. The ideal population satisfying the best answer to the problem is found by moving the particles through the exploration field. In a multidimensional exploration field, particles are formed, and each one uses information from nearby particles as well as its own experience to alter its position. Additionally, particles are led by the ideal position that they and their nearby particles have found [41]. The PSO has the advantages of being simple to execute and requiring few parameter tweaks.



Mirjalili et al., [42], introduced the GWO for the first time. It draws inspiration from the actions and tactics used by grey wolves in the wild [43]. The grey wolves adhere to a strict leadership order within their packs. Alpha (a) wolves are the name given to the pack's leaders. The following group of grey wolves is regarded as one of the secondary ones. They aid the dominant species. The beta (b) wolves are the name given to them. Delta (d) wolves also have a lower priority level than alpha and beta wolves. Their goal is to govern the omega wolves while yielding to the alpha and beta wolves. The omegas (x), which must lag behind the leading grey wolves, are the least important wolves [44].A, B, F, O, and P. To handle the ORPD problem, Case 2's GWO-PSO optimization technique attained the lowest voltage deviation when compared to other well-known optimization strategies, as shown and summarised in Tables 7 and 8. The hybrid GWO-PSO can obtain the optimal solution for the objective functions thanks to this comparison illustration of the outcomes. Multiple trials were conducted for both case 1 and case 2 to ensure the reliability of the newly developed GWO-PSO optimization technique for tackling the ORPD problem.Figs. 5 and 6 display the convergence curves of the proposed algorithm and the PSO algorithm for cases 1 and 2 after 2000 iterations on the 30-bus system. The solutions for the IEEE 30-bus test system fitness functions can be seen to be effective and competitive. The GWO-PSO optimization methodology yielded the best results out of all the other investigated methods in terms of both the value of power losses in case 1 and the value of voltage variation.

III. RESULTS

The suggested FPSO algorithm for handling the numerous multi-area OPF problems. The standard IEEE 30-bus system and an interconnected two-area system created by joining two identical standard TEEE 30-bus systems with a tie-line and planned interchange from area to area are used to test FACTS controllers.The fuzzy logic data are identical to those in Table 2.2 for the computation of the inertia weight of generated active power, voltage magnitude of voltage controlled buses, voltage magnitude of SVC connected buses, voltage magnitude of STATCOM connected buses, reactance of TCSC and injected voltage magnitude, phase angle, and quadrature current of UPFC.The simulations were run on a Pentium IV CPU running at 2.5 GHz. The following parameters are employed in the PSO and FPSO approaches. The SVC is situated on IEEE 30-bus system bus 21. Its voltage limitations are 0.9 and 1.1 pu, and its reactive power limits are 11.2 MVAr (capacitive) and -2.5 MVAr (inductive). Table 5.1 presents the best possible solution for the TEEE 30-bus system utilising the suggested method and SVC.

TABLE

IEEE 30-Bus System Optimal Solution with SVC at Bus 21

Algorithm	EP	TS	PSO	FPSO
PG1 (MW)	151.61	151.64	151.21	151.6
PG2 (MW)	57.034	56.165	57.344	56.862
PG5 (MW)	24.222	22.463	23.185	23.315
PG8 (MW)	26.095	30	28.815	29.533
PG11 (MW)	17.243	16.318	15.046	16.401
PG13 (MW)	15.383	15.118	15.994	13.904
V1 (p.u)	1.0484	1.0498	1.0499	1.05
V2 (p.u)	1.0332	1.0322	1.0358	1.0354
V5 (p.u)	1.009	0.9953	1.0137	1.0006
V8 (p.u)	1.0208	1.018	1.0235	1.0225
V11 (p.u)	1.0432	0.9869	1.043	1.0495
V13 (p.u)	1.0393	1.0384	1.0202	1.0332
VSVC (p.u)	0.9784	0.9787	0.9785	0.9783
Q SVC (MVAr)	6.6778	10.148	6.0379	2.5785
Total PG (MW)	291.58	291.7	291.59	291.61
Total QG (MVAr)	63.285	60.331	63.831	67.963
Loss (MW)	8.1813	8.1814	8.1813	8.2104
Total Fuel cost ($/hr)	808.74	808.68	808.59	808.48
Number of Iterations	350	300	270	220
Computation Time (sec)	60	45	40	35

TCSC is situated in line 4 of area | and SVC is situated at bus 21 of area 2 for the integrated two area test system. The TCSC and SVC ratings are identical to those previously mentioned. The best solutions for the multi-area OPF problem with TCSC in area | and SVC in area 2,which is based on the suggested FPSO algorithm, are shown in Tables 5.5.

TABLE

PSO and FPSO Based Algorithms for the Optimal Multi-Area OPF with Multiple FACTS Controllers

Area	Area 1 sub-problem		Area 2 sub-problem	
Algorithm	**PSO**	**FPSO**	**PSO**	**FPSO**
PG1 (MW)	155.123	155.101	149.432	148.662
PG2 (MW)	58.753	58.362	49.263	48.871
PG5 (MW)	25.396	25.387	23.491	23.443
PG8 (MW)	29.045	29.024	27.021	26.933
PG11 (MW)	21.066	21.032	20.638	20.561
PG13 (MW)	22.058	22.263	18.322	18.243
V1 (p.u)	1.050	1.050	1.050	1.049
V2 (p.u)	1.031	1.031	1.030	1.030
V5 (p.u)	0.985	1.013	0.984	1.012
V8 (p.u)	1.012	1.012	1.012	0.993
V11 (p.u)	1.003	1.002	1.001	0.997
V13 (p.u)	1.000	0.998	1.012	1.021
Xc (p.u ohm)	0.027	0.026	--	--
Q SVC (MVAr)	--	--	11.200	11.041
Total PG (MW)	311.562	311.220	287.882	286.503
Total QG (MVAr)	75.620	74.270	69.230	70.770
Loss (MW)	8.925	8.823	9.032	8.952
Total Fuel cost ($/hr)	810.145	809.910	788.470	785.287
Number of iterations	350	300	270	220
Computation time (sec)	60	45	40	35

From the table, it can be deduced that the FPSO algorithm requires fewer iterations and takes less time to calculate the same optimal solution than the PSO technique. It is implied that the overall fuel cost of each area will decrease with the addition of TCSC to line 4 in area 1 and SVC to bus 21 in area 2. The capacity of the line to transfer power has increased with the addition of TCSC, and the addition of SVC has resulted in the voltage profile of the system being well within its limits, ensuring voltage stability and improving steady state stability at the power transfer limit of the multi-area power system.The FPSO algorithm is therefore straightforward and effective for multi-area OPFa multiple FACTS controller issue.

IV. CONCLUSION

In order to address the power economic dispatch issues, the proposed study work provides three effective algorithms, namely GWO-PSO, GWO-PSO-T, and MOEP. These three strategies each offer advantages and skills that can be used to address different power economic dispatch-related issues. Numerous examples and case studies have been provided to show how well these suggested optimization strategies may be used to address power economic dispatch issues. The results of this projected work are described, and useful recommendations for further study within the scope of this issue are also provided.The following is a summary of the main contributions of this research work: This study formulates a non-convex optimization problem for a more realistic economic dispatch with valve point effects and different fuel options. The complicated and non-convex ED issue is solved in this study using an unique Grey Wolf Optimization (GWO-PSO) technique, and better optimal solutions are produced. 164 The GWO-PSO method's performance and capabilities are examined and contrasted with those of the Particle Swarm Optimization algorithm. The environmental economic dispatch problem is represented as an optimization problem where the numerous competing objectives are simultaneously optimised.Two objectives are first taken into account while using the GWO-PSO-T algorithm, and then three and four objectives are added afterwards. For each of the three scenarios under consideration, the ideal solutions are discovered, and the outcomes are assessed against other optimization techniques described in the literature. Through the suggested study, the multi objective environmental economic dispatch problems are solved using a novel multi objective optimization approach called Multi Objective Evolutionary Programming (MOEP).To increase performance in MOEP-based optimization, non-dominated solution ranking and a diversity-preserving technique using clustering are used. It is suggested that the scaling factor change over time to increase algorithm efficiency.By contrasting the outcomes and Pareto-optimal front solutions with the outcomes of MOPSO and other MOEAs described in literature, the efficacy of MOEP is shown. 165 Performance indicators are used to assess the superiority of the proposed MOEP approaches, and the outcomes are contrasted with those of MOPSO. The effective single goal and multi objective optimization techniques provided in this suggested study can be used to quickly handle power dispatch issues.

RESEARCH SUGGESTIONS FOR THE FUTURE

The following areas may be the subject of future research: By reevaluating the difficulties brought on by the introduction of competition in the power industry, the optimization issues connected to power economic dispatch may be updated with more realistic objective functions and restrictions.It may be suggested to use the improved neighbourhood selection strategies to speed up the GWO-PSO algorithm's processing of non-convex optimization problems.The GA and PSO tool box in the MATLAB environment is similar to how the GWO-PSO tool box may be built to be more effective for real-time applications. With a better Pareto optimum front solutions selection process, which will perform better for more than two objectives, the MOEP performance may be enhanced. It is possible to provide a method for resolving numerous objective optimization issues in order to address real-world applications relating to the power system.