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Implementation of Hybrid Algorithm for Solving OPF Problem in a Distribution System Environment

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ABSTRACT

The present day power system scenario faces many challenges that includes liberalized energy market or large penetration of renewable energy sources. These sources are essential to manage the day to day increasing energy needs. For decades researchers have developed various models and algorithms for Optimal Power Flow (OPF) in different applications. Traditional mathematical optimization methods have been used to effectively solve conventional OPF problems. Due to the emergence of a deregulated electricity market and consideration of dynamic system properties, problem of convergence and lack of accuracy overruled traditional concepts of power system with the development of advancements. The purpose of this paper proposes a hybrid algorithm combining Sequential Quadratic Programming (SQP) and Modified Improved Particle Swarm Optimization (MIPSO) algorithm for solving the OPF problem. In this method, SQP is used to generate an individual; MIPSO algorithm can reach the optimal solution more effectively than classical evolutionary algorithms. The proposed method has been used to solve the OPF problem on standard IEEE 14 bus test system. The main objectives namely fuel cost and transmission line losses have been considered. The results obtained from the proposed method gives better solution for non-convexity problem.

Index Terms: Optimal Power flow (OPF), Sequential Quadratic Programming (SQP), Modified Improved Particle Swarm Optimization (MIPSO).

1. INTRODUCTION

The optimal power flow and economic load dispatch problems are the fundamental issues in power system planning and operation which is a large scale, nonlinear, non-convex, static optimization problem which computes optimal settings of electric variables under the condition of constraints imposed by operational and physical particulars of the electric network. There are many artificial intelligence methods such as Genetic Algorithm (GE), Evolutionary Programming (EP), Differential Evolution (DE), Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO) have been used for solving these OPF problem [1].

Optimization is the act of obtaining the best result under given circumstances, which is the process of finding the conditions that give the maximum or minimum value of a function [2]. The objective of the OPF algorithm is finding the steady state operating point which minimizes the system operation cost, power transmission losses. In recent past, a hybrid algorithm developed by combining the merits of two different algorithms have been reported in literature for solving the OPF problem shows more non-complexity and stagnature problem [3].

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The idea of this paper is also in new type of hybrid algorithm, which involved the combining of SQP and MIPSO algorithm in order to solve the OPF problem without considering the valve point effects [5]. Initially in this scheme, SQP is primarily used to solve the OPF problem by relaxing the discrete variables and the obtained primary solution, gets rounded off and this value is feeded to initial value to MIPSO algorithm in order to get the optimal global solution [6].

By this method the problem of IPSO algorithm like non-convexity, stagnation and convergence can be eliminated. The proposed method is tested in a IEEE 13 bus system [7]. The main factors that are considered in this paper is fuel cost, transmission line losses were taken. The results show that the proposed method is able to achieve better solution than other hybrid concepts [8].

1.1. OPF Problem Formulation

Considering in power systems the need of the OPF problem involves the minimization of nonlinear objective function includes nonlinear load flow equations and inequality constraints are satisfied. For a constrained optimization the OPF problem as follows:

$$\text{Minimize } F(V, Y) \tag{1}$$

$$\text{Subject to } G(V, Y) \tag{2}$$

$$H(V, Y) \tag{3}$$

Where V states the vector of involved control variables that can be controlled by system operator also Y is the vector of the dependent variables[9]. In the function $F(V, Y)$ is considered as the objective to be optimized, it can be an active power production cost, transmission losses. The objective includes the minimization of the fuel cost of the operating system F_t which is considered in the form of quadratic cost function, also the minimization of real power transmission line losses P_l of the considered system.

2. SEQUENTIAL QUADRATIC PROGRAMMING

SQP is a special form of nonlinear programming, its objective function must involve quadratic and constraints must be linear. This method outperforms every other nonlinear programming method in terms of accuracy factor, efficiency and percentage of successful solutions over large test problems [10]. This method closely resembles Newton's method for constrained optimization. At each iteration an optimization is made. The result of the approximation is then used to generate a MIPSO sub-problem whose solution is used to form a search direction for a line search procedure. SQP is a local optimization method it ensure a local minimum for an optimization problem.

3. INTRODUCTION OF PSO

The concept was introduced by Kennedy and eberhart, the merit is that it is a heuristic optimization technique that inspired by swarm intelligence of bird flocking, fish schooling [11]. A swarm of particles represent a candidate solution to be optimization problem. Each particle adjusts its position according to its own experiences. This is considered to be a factor of advantage in using this algorithm. The position and velocity of the n th particle in all population is considered to get a optimal solution.

4. COMBINING SQP AND MIPSO ALGORITHM

In this paper, SQP is combined with the MIPSO algorithm to form a hybrid algorithm for solving the OPF problem. First SQP is used to solve the OPF problem by relaxing the discrete variables. The solution obtained from SQP is rounded off to the nearest integer and given to the initial population of MIPSO algorithm as a special individual. In initial population, all individuals are randomly generated. Since the special individual obtained from the basic algorithm is used in second algorithms evolution process. The problem of stagnation and premature convergence of IPSO can be eliminated in this scheme. This is found to be more suitable to solve OPF Problem.

The formation of the structure of the hybrid concept is explained with the help of the steps shown here. Initially the performance is analyzed by summing the population of the distribution line system. With this parameter then followed with the initial velocity of all the particles assigned to a specified range which is then followed by the number of operation count and the obtained best value is then feeded to the MIPSO scheme, where the obtained best result of the NR method is analyzed to find out the best optimal solution. The obtains global optimum solution of each run is recorded which then leads to the finding of the best optimal value. The steps involved in this hybrid algorithm are listed below.

Steps Involved in Hybrid Algorithm

Step 1: Initialization of population size, number of value.

Step 2: Initial velocity and population of all particles are assigned within their specified range.

Step 3: Involves the generation count $k = 1$ and $i = 1$.

Step 4: Using Newton's method solve for each particle.

Step 5: The obtained values during this run is approximated and feeded as a initial values for MIPSO algorithm.

Step 6: Obtain the Global Values during each run.

Step 7: update the velocity by using the global best and individual best of each particle.

Step 8: According to the obtained best value update positions of each particles.

Step 9: Check the iteration count.

Step 10: Run the program until the maximum iteration count.

Step 11: Stop the program.

5. NUMERICAL RESULT ANALYSIS

The performance of the hybrid concept based algorithm in the solution of solve optimal power flow problems, the proposed algorithm was tested in a IEEE 13 bus test system. The algorithm is implemented in a computational environment of MATLAB. The load demand of the system is considered as 1800MW. The primary parameter setting of the 14 unit system is given below [5].

The table 1 in the analysis is provided with the primary parameter values. Here the number of the generation count is accounted as 200 and the swarm size accounted here is counted as 20, the maximum

Table 1
Primary parameters setting

Primary parameters setting	
Generations	200
Swarm size	20
Max. iterations	100
Maximum inertia weight	1.3
Minimum inertia weight	0.3
Maximum cognitive factors	2.2
Minimum cognitive factors	1.4
Maximum social factors	2.2
Minimum social factors	1.5

Table 2
Results of 14bus unit system

Unit	Results of 14 bus unit system			
	P Min	P max	Generation (MW)	Cost ($)
1	0	670	538.6547	4993.3425
2	0	360	150.4032	1547.4523
3	0	360	119.4321	2152.631
4	60	180	119.4321	1129.3481
5	60	180	119.4321	1129.3481
6	60	180	119.4321	1129.3481
7	60	180	119.4321	1129.3481
8	60	180	119.4321	1129.3481
9	60	180	119.4321	1129.3481
10	42	120	77.8635	808.2459
11	42	120	40.0003	474.2341
12	50	120	55.7689	607.8092
13	50	120	55.7892	607.8092
14	50	120	55.6285	607.2347
	Total generation and cost using hybrid algorithm		1,810.133	18,574.84

Table 3
Comparison Result

Method	Comparison Result		
	Fuel cost, $/h		
	Best	Mean	Worst
Available MIPSO	572.232	572.238	575.399
Proposedmethod	572.155	572.24	572.543

number of iterations accounted here is 1000, the maximum and minimum inertia weighted is shown in the table 1 with the operating ranges of maximum and minimum factors. The parameter settings are shown in table 1.

The above table provides the primary parameter setting values. The table 2 provides the value of total generation cost of an IEEE 13 bus test system. Here the table provides the amount of power production at each bus test system and the corresponding power production. The resultant estimation cost is shown in the table 2.

The comparison of the available modified improved particle swarm optimization scheme and the proposed hybrid algorithm with the sequential quadratic programming based modified improved particle swarm optimization is tabulated in table 3.

6. CONCLUSION

This paper proposed a hybrid method combining SQP and MIPSO algorithms to solve for OPF problem. The deterministic methods, like SQP are best methods to find the optimal solution when the type is differentiable and convex. The usual problem of it is lacking in ability to find solution for non-convex

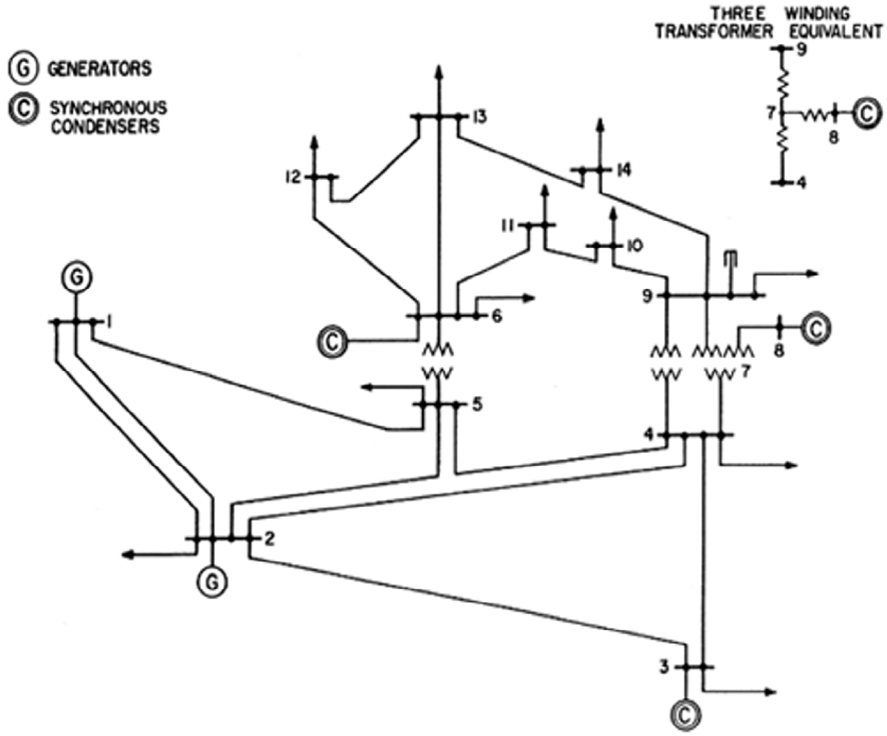

Figure 1: IEEE 14-Bus system

BUS VOLTAGES AT THE END OF 100 ITERATIONS
E(1)=(1.070000)+j(0.000010)
E(2)=(1.051071)+j(-0.090348)
E(3)=(0.998012)+j(-0.216878)
E(4)=(1.004306)+j(-0.171884)
E(5)=(1.008447)+j(-0.155282)
E(6)=(1.037393)+j(-0.261998)
E(7)=(1.033411)+j(-0.244615)
E(8)=(1.080686)+j(-0.251088)
E(9)=(1.050843)+j(-0.221512)
E(10)=(1.085241)+j(-0.273020)
E(11)=(1.022244)+j(-0.269053)
E(12)=(1.089093)+j(-0.273569)
E(13)=(1.034097)+j(-0.273800)
E(14)=(0.998706)+j(-0.285303)

functions. This best nonlinear algorithm in comparison with the evolutionary algorithms like MIPSO has the ability to find the optimal solution.

The paper proposed new method by overcoming the drawbacks of either method; the SQP is used to give a special individual to initial population of MIPSO. This contains higher fitness functions than the normal individual; this algorithm is achieving the global optimum solution than a local optimum. The proposed method has been tested on an IEEE standard system the result gives a positive feedback of better solution than the classical approach. It shows the proposed method is more suitable to solve for non-convex function.

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