HYBRID APPROACH TO THE ECONOMIC DISPATCH PROBLEM USING A GENETIC AND A QUASI-NEWTON ALGORITHMS

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ABSTRACT

In this paper, we present a hybrid optimization approach to solving the economic dispatch (ED) problem. The objective is to minimize the total fuel cost and keep the power flows within the security limits. The idea consists in combining principles from real coded genetic algorithms (RCGAs) [1] and a parallel quasi-Newton method (QN), in order to find a better compromise trade-off and a better precision while requiring a reasonable computing time. The approach that is presented utilizes both local and global optimization algorithms to find good design points more efficiently than either could. A parallel quasi-Newton method is used to explore the space of research and exploit all local information to progress towards a better point.

The proposed approach improves the equality of the solution and speed of convergence of the algorithms. The hybrid methods developed is compared with a RCGAs and a classical methods of QN.

The proposed approach has been tested on the IEEE 57 bus system [2].

Keywords: *economic dispatch, real power optimization, real coded genetic Algorithms, quasi-Newton methods.*

1. INTRODUCTION

Economic dispatch is one of the most important operational functions of the modern clay energy management system. The economic dispatch aims to minimize the fuel cost while provides consumers with adequate and secure electricity. A lot of research work has been carried out in the past in economic load dispatch [3,4,5] using several optimization techniques including classical, linear, quadratic and nonlinear programming methods.

Recently, a global optimization technique known as genetic algorithms (GAs) which is a kind of the probabilistic heuristic algorithm has been studied to solve the power optimization problems. The GAs may find the several sub-optimum solutions within a realistic computation time.

The method of QN (which it is based on the nonlinear programming) explores the space of research by using a single point and exploits all local information to progress towards a better point.

This paper presents a hybrid method (GA.QN) combining a real coded genetic algorithms and a parallel quasi-Newton method.

The efficiency and the robustness of the proposed approach are demonstrated by test functions.

In order to investigate its performance, the proposed approach is compared with a RCGAs and classical methods of Quasi-Newton BFGS (Broyden-Fletcher-Goldfarb-Shanno) [5].

The proposed approach has been tested on the IEEE 57-bus system [2].

2. PROBLEM FORMULATION

Economic dispatch is the important component of power system optimization. It is defined as the minimization of the combination of the power generation, which minimizes the total cost while satisfying the balance relation.

The economic dispatch problem can be formulated as:

$$Min\left\{F(P_G)=\sum_{i=1}^{NG} f_i(P_{Gi})\right\} \tag{1}$$

$$f_i(P_{Gi})=a_iP_{Gi}^2+b_iP_{Gi}+c_i \tag{2}$$

Where F is the total cost ($/h), f_i the operating cost of unit i ($/h), N_G number of generators including the slack bus and a_i, b_i, c_i, the generator cost coefficient. P_{Gi} is the real power output of the i-th generator (MW).

Subject to equality constraint

$$\sum_{i=1}^{NG}(P_{Gi})-P_D-P_L=0 \tag{3}$$

And inequality constraints

$$P_{Gi}^{\min}\le P_{Gi}\le P_{Gi}^{\max} \tag{4}$$

where:

$$P_L=\sum_{i=1}^{N}\sum_{j=1}^{N}P_{Gi}B_{ij}P_{Gj}+\sum_{i=1}^{N}B_{0i}P_{Gi}+B_{00} \tag{5}$$

D : total demand (MW)
P_L : transmission losses (MW)
P_{Gi}^{max} : maximum generation output of the i-th generator
P_{Gi}^{min} : minimum generation output of the i-th generator
B : coefficients of transmission losses

By applying a penalty function we transform a constrained non-linear ED problem into an unconstrained problem.

We can rewrite the problem shown in (1) as:

$$F_m = F(P_G) + r_k \sum_{i=1}^{NG} g_i^2(P_{Gi}) + \frac{1}{r_k} h^2(P_G) \quad (6)$$

Where the value of the penalty coefficient r_k is checked at each iteration.

$g_i(P_G)$ is a in-equality of real power limits
$h(P_G)$ is a equality constraint :

$$h(P_{Gi}) = \sum_{i=1}^{NG} P_{Gi} - P_D - P_L \quad (7)$$

3. GENETIC ALGORITHMS

GAs are search algorithm base on mechanics of natural selection and natural genetics [6]. The law of coincidence takes advantage of information in order to derive improvement from it.

GAs is algorithm for optimization based on the principle of biological evolution. They are unlike many conventional search algorithms in the sense that they simultaneously consider may points in the search space. They work not with the parameters themselves but with string of number representing the parameter set. And they are probabilistic rules to guide their search. By considering many points in the search space simultaneously reduce the chance of converging to local minim. The process of GAs follows this pattern [6, 7].

- ✓ An initial population of random solution is created.
- ✓ Each member of population is assigned a fitness value based on its evaluation against the current problem.
- ✓ Solutions with high fitness value are most likely to parent new solutions during reproduction.
- ✓ The new solution set replace the old, a generation is completed and the process continues at step (2)

The algorithm improves each individual solution by combining and transferring the beneficial characteristics of highly parents to their off string. Members of the population are represented as bit strings, which are improved repeatedly with a series of genetic operators, known as reproduction, crossover and mutation. This simple genetic procedure consistently produces even fitter offspring through successive generations, which gradually leads the search towards the optimal point.

When this genetic approach is reflected in computing language, it involves nothing more than string copying and partial string exchanging, yet it can attain good results in circumstances which are resistant to known methods. The simplicity of the computational procedure and the powerful search ability of GAs have attracted wide attention in various engineering field, such as function optimization, gas pipe control, game playing pattern recognition and electric power scheduling [5]. The further attraction is that they are extremely robust with respect to complexity of the problem.

4. HYBRID APPROACH

GAs can be cross with considerable techniques of exploration specifically adapted to a problem with a particular problem in order to form a hybrid which exploits the total prospect for GAs and the convergence of the specific technique [8].

The local optimization of a continuous function of at least a variable is a very advanced art, and of many techniques using or not the gradient making it possible to find optima local. To develop hybrid GAs for such a function, it is enough to cross its method of local exploration preferred with GAs In a sense, GAs finds the hills and local method the climbing. There are several means of hydride GAs all while maintaining a structure of program rather modular. We propose two hybrid methods

4.1. Hybrid algorithm according to the principle of Darwin (GA.QN.D)

By successive iterations, GAs provide the best gradually estimated initial for algorithms QN (the latter can work in parallel). The starting points of QN become gradually those which, placed well inside the basin of attraction of the total minimum, will surely evolve to this optimum. During the evaluation of the quality of each individual, GAs uses the results of a climbing QN whose initial point corresponds to this individual. During the phases of reproduction and genetic transformations (crossover, mutation) for the generation of new individuals, GAs handle the initial values given previously to QN and not the results provided by the latter (Fig.1).

4.2. Hybrid algorithm according to the principle of Lamarck (GA.QN.L)

By successive iterations, GAs gradually provides better solutions by using QN like an accelerating mechanism thanks to its properties of exploitation. At the time to evaluate the quality of adaptation of each individual, GAs use the results of a climbing QN working with one considered initial corresponding to this individual. During the phases of reproduction and genetic transformations (crossover, mutation) for the generation of new individuals, GAs handle new the solutions (final points) found by QN (Fig.2).

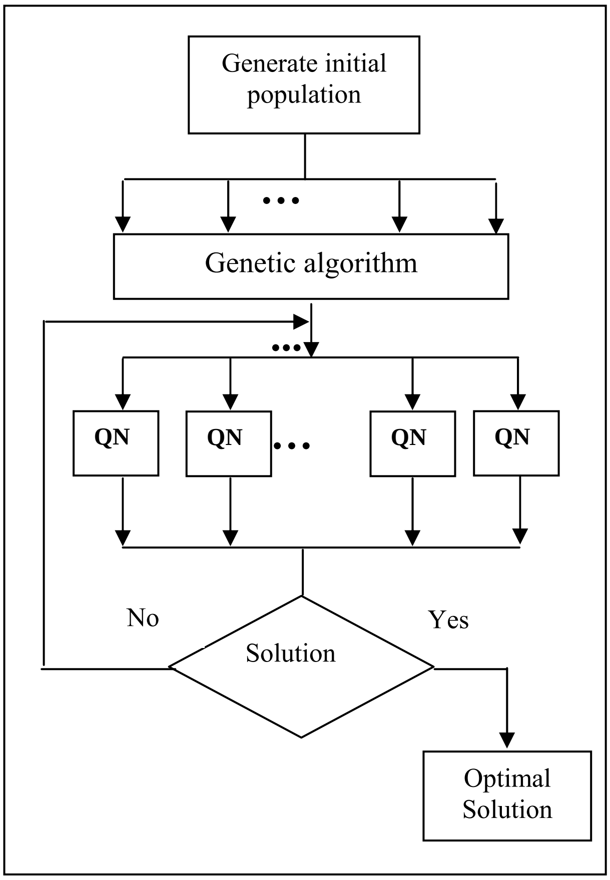

Fig. 1 The schematic representation of the principle of hybridization according to Darwin (GA.QN.D).

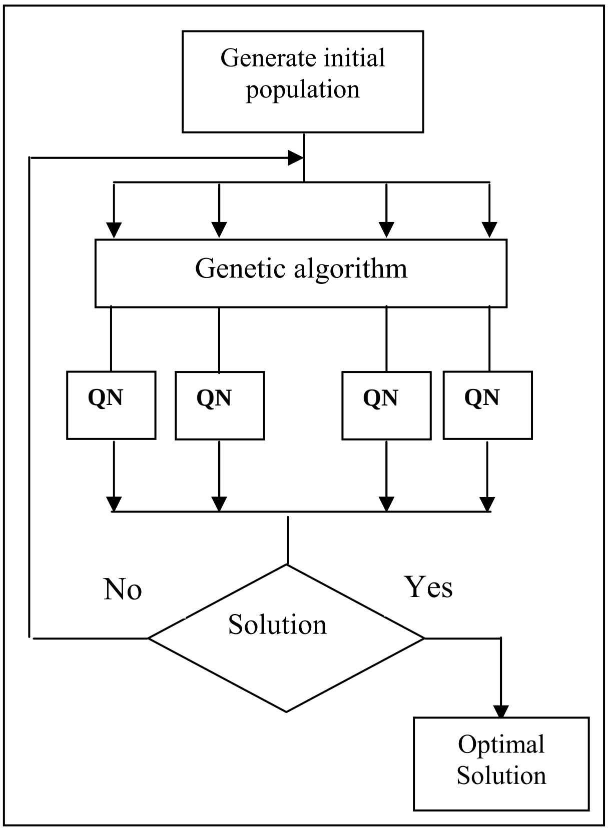

Fig. 2 The schematic representation of the principle of hybridization according to Lamarck (GA.QN.L).

5. TEST AND RESULTS

The proposed method was applied to the electrical network on IEEE 57 bus [2] to assess the suitability of the algorithm. The fuel cost (in $/hr) equations for the five generators are:

$F_1 (P_{G1}) = 0.0776\, P_{G1}^2 + 20.0\, P_{G1} + 0.0$
$F_2 (P_{G2}) = 0.0100\, P_{G2}^2 + 40.0\, P_{G2} + 0.0$
$F_3 (P_{G3}) = 0.2500\, P_{G3}^2 + 20.0\, P_{G3} + 0.0$
$F_6 (P_{G6}) = 0.0100\, P_{G6}^2 + 40.0\, P_{G6} + 0.0$
$F_8 (P_{G8}) = 0.0222\, P_{G8}^2 + 20.0\, P_{G8} + 0.0$
$F_9 (P_{G9}) = 0.0100\, P_{G9}^2 + 40.0\, P_{G9} + 0.0$
$F_{12} (P_{G12}) = 0.0323\, P_{G12}^2 + 20.0\, P_{G12} + 0.0$

And the constraints are: (the unit operating ranges in MW are):

$0.0 \leq P_{G1} \leq 575.88$
$0.0 \leq P_{G2} \leq 100.00$
$0.0 \leq P_{G3} \leq 140.00$
$0.0 \leq P_{G6} \leq 100.00$
$0.0 \leq P_{G8} \leq 550.00$
$0.0 \leq P_{G9} \leq 100.00$
$0.0 \leq P_{G12} \leq 410.00$

The total load was $P_D = 1250.8$ MW.

Transmission losses P_L are computed using the B coefficients.

The proposed method was implemented in Matlab 6.5 with P-IV 2.66GHz system.

5.1. Parameters values for GAs

The RCGAs has a number of parameters that must be selected. These include population size, crossover, mutation probability and number of generations:

- Population size : 300 ;
- Crossover probability: 0.75;
- Crossover operation: single point;
- Mutation probability: 0.006.

The minimum cost and active power generations are presented in Tab.1.

From the table1, the minimum cost of GA.QN.L method is better than GA.QN.D. The GA.QN.L demonstrated faster convergence then GA.QN.D.

In Tab.2, the results of proposed method are compared with the results of RCGAs, BFGS and "MATPOWER" (a Matlab power system simulation package [ZIM 97].

It is seen that the minimum cost of the proposed approach is better than RCGAs, BFGS and MATPOWER.

The BFGS method produced a higher operation cost than other methods.

The total computational time of the proposed approach is far less than for the RCGAs and MATPOWER.

Table 1 Results of hybrid approach

	Hybrid approach GA.QN.D	Hybrid approach GA.QN.L
P_{G1}^{opt} (MW)	140.5228	140.5339
P_{G2}^{opt} (MW)	86.5380	86.4187
P_{G3}^{opt} (MW)	43.5069	43.5386
P_{G6}^{opt} (MW)	86.0782	86.4366
P_{G8}^{opt} (MW)	487.4176	487.3365
P_{G9}^{opt} (MW)	87.1946	86.4282
P_{G12}^{opt} (MW)	336.2400	336.3056
cost ($/h)	41703	41682
time (sec)	25	15

Table 2 Results of hybrid approach compared with RCGAs, BFGS and MATPOWER methods

	RCGA	BFGS	Hybrid approach GA.QN.D	Hybrid approach GA.QN.L	MAT-POWER
P_{G1}^{opt} (MW)	189.93	261.87	140.52	140.53	142.63
P_{G2}^{opt} (MW)	89.73	108.31	86.53	86.41	87.79
P_{G3}^{opt} (MW)	75.13	49.88	43.50	43.53	45.07
P_{G6}^{opt} (MW)	26.35	108.31	86.07	86.43	72.86
P_{G8}^{opt} (MW)	526.36	356.96	487.41	487.33	459.81
P_{G9}^{opt} (MW)	90.94	108.31	87.19	86.42	97.63
P_{G12}^{opt} (MW)	277.93	280.71	336.24	336.30	361.52
cost ($/h)	42698	43657	41703	41682	41737
time (sec)	34	6	25	15	38.72

6. CONCLUSION

In this paper, a hybrid approach to the economic dispatch problem has been presented and compared with a RCGAs and classical optimization technique of BFGS.

The proposed technique improves the quality of the solution and reduces the computation time.

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Received February 25, 2007, accepted July 17, 2008

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