International Journal of Soft Computing 2 (3): 373-377, 2007

An Efficient Genetic a Lgorithm to Solve the Problem of the STEG Economic Power Dispatch

[1]I. Bekri-Abbes, [2]H. Rahmouni and [1]N. Ghrab-Marcos
[1]Department Génie Industriel (DGI) Ecole Nationale d'Ingénieurs de Tunis, Tunis-ElManar, Tunisia
[2]Department of Technical Production of Electricity of the STEG

Abstract: In the new competitive electricity supply industry, there is a renewed interest in algorithms that can provide saving in operation cost. An optimal scheduling of generators can provide substantial annual saving in fuels costs. But this highly constrained non linear mixed integer optimization problem can only be fully solved by complete enumeration, a process which is not computationally feasible for realistic power systems. An attempt has been made in this research to solve the problem of power economic dispatch of the Societé Tunisienne d'Electricité et du Gaz (STEG) using Genetic Algorithm.

Key words: Economic power dispatch, genetic algorithm, spinning reserve, load demand

INTRODUCTION

The Economic Power Dispatching (EPD) is one of key problems in power system operation and planning. This may be expressed by minimizing the fuel cost of generators units under constraints depending on load variations, the output of generators has to be changed to meet the balance between loads and generation. Therefore, the EPD is one of the fundamental problems in power system operation and planning. The primary objective of the Economic Dispatch (ED) issue is to determine the allocation of the load among the units in order to supply the load demand at minimum cost, which is subject to a numbers of system and units constraints.

A number of methods have been previously proposed for solving this problem. Methods used provide only near optimum solutions and the quality of each solution is affected by either the solution time limitation or by the feasibility of the final solution. Computer storage requirement used to be another major limiting factor.

Recently, there has been a great deal of interest in promising Genetic Algorithm (GA) (Michalewicz, 1995, 1996; Gil and Bustos, 2002) and its application to various disciplines including power system planning operation and control. Genetic algorithms are also being applied to a wide range of optimization and learning problems in many domains; unit commitment (Arroyo and Onejo, 2002) capacitor placement problem (Ghose *et al*., 1999) reactive power optimization (Iba, 1994) and economic power dispatch (Youssef and El-Naggar, 2000; Xiangping *et al*., 2000; Osman *et al*., 2004; Su and Chiang, 2004).

Genetic Algorithm (GAs) are adaptive evolutionary methods which can be used to solve search and optimization problems such as this one. They are based on the genetic processes of biological organisms. Over many generations, natural populations evolve according to the principles of natural selection and survival of the fittest. By mimicking this process, genetic algorithms are able to evolve solutions to real world problems.

They work with a population of individuals, each representing a possible solution. Each individual is assigned a fitness score according to how good the solution solves the problem. Individual solutions with a high fitness value are given opportunities to reproduce, by breeding with other fit individual solutions in the population.

This produces new individuals as offspring, which share some features taken from each parent. The least fit members of the population are less likely to be selected for reproduction and so they die off. A whole new population of possible solutions is thus produced by selecting the best individuals from the current generation and mating them to produce a new set of individuals. If the GA is well-designed, the population will converge to the optimal solution to the problem.

In Tunisia, the demand of electricity is satisfied by the Société Tunisienne d'Electricité et du Gaz; STEG. Which disposes of a variety of electric units; hydro-

Corresponding Author: I.Bekri-Abbes, Department Génie Industriel (DGI) Ecole Nationale d'Ingénieurs de Tunis, Tunis-ElManar, Tunisia

power units and thermal generators, the planning of hydro-power generator is determined exclusively by the ministry of agriculture.

The majority of electricity is provided by thermal generators. Thermal generators are consisting of a combined cycle, 10 steam turbines and 15 gas turbines. In order to satisfy the load, the STEG follows some strategies: Steam turbines, when available, are always in working, because the cost of start up is extremely important. However, gas turbines are in working only in period of day where there is fluctuation of the electricity. This strategy, although it apparently efficient, is not based on an informatic program.

This research is an attempt to solve this problem using an informatic program based on genetic algorithm.

GENETIC ALGORITHM IMPLEMENTATION

Problem formulation: The goal of the economic power dispatch is the scheduling of the power outputs for each committed unit so that the total operating cost is minimized and the customer load demand is met. The objective is therefore to minimize the total power production cost for the system with N generators.

$$F=\sum_{i=1}^{N} F_i=\sum_{i=1}^{N} (a_{i0}+a_{i1}Pi+a_{i2}Pi^2+a_{i3}P_i^3+a_{i4}P_i^4+a_{i5}P_i^5$$

The fuel cost F is a quadratic function of power generators system. a_{i0}, a_{i1}, a_{i2}, a_{i3}, a_{i4} and a_{i5} represent the cost coefficients for unit i and they are the input of the problem while Pi is the power of unit i and it represents the output of our problem.

The overall objective is to minimise F which is subject to a number of constraints:

- The spinning reserve requirements R must be met

$$\sum_{i=1}^{N}\left(\frac{P_{i\max}-P_{i\min}}{2}\right)\sum_{i=1}^{N} yiPi \geq R$$

$$yi=\begin{cases}1 \text{Unit i is in working}\\ 0 \text{ else}\end{cases}$$

- The total power balance must supply the load demand P_D

$$\sum_{i=1}^{N} Pi=P_D$$

- The minimum and maximum capacities must not be violated

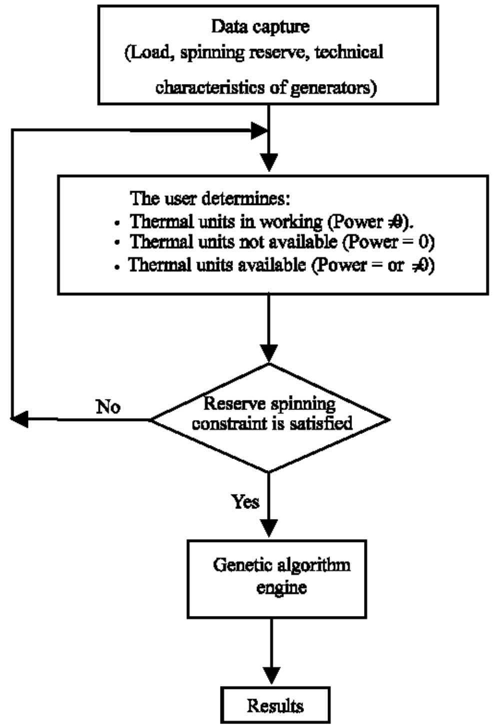

Fig. 1: Principal program

$$P_{i_{min}} \leq P_i \leq P_{i_{max}}$$

It is important to mention here that the system losses have been ignored for simplification purposes.

Global algorithm: The global program is represented in Fig.1. The user determines in this interface, generators not available (which are in maintenance), generators that must work (their power must be±0) and available generators.

Genetic algorithm: The implementation of the genetic algorithm to any optimization problem is straightforward and simply requires the implementation of the three genetic operators, i.e., reproduction, crossover and mutation. The proper fitness function and the composition of the genetic strings are problem specific.

The adopted representation of the chromosome is a real one. Each individual is a string of different power of generators.

Initial generation and procedure of correction: An initial solution is generated as follows. Only individuals that satisfied the constraint of minimum and maximum technical power and the constraint of load balance are created, the creation of initial population is illustrated in Fig. 2.

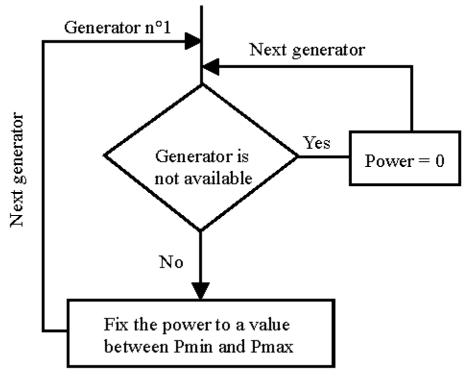

Fig. 2: Diagram of the procedure of creation of initial

If the generator is available, we associate to it a power which satisfy the constraint of maximum and minimum, to ensure this constraint, the power Pi associated to thermal generator i satisfy the following equation:

$$Pi = Cv[i]*(Pi_{min} + \beta*(Pi_{max} \; Pi_{min}))$$
$$\beta \in [1,2]$$
$$Cv[i] = \begin{cases} 0 \text{ if i is a generator not available} \\ 1 \text{ if i is a generator in working or available} \end{cases}$$

This equation allows the creation of an initial population of individuals which satisfy the constraint of minimum and maximum power but not that of the load balance, in order toensure this constraint, the following algorithm is applied.

```
Begin
   Repeat
  Calculate total power of generators;
 α = PD / total power; {PD is the load}
  For i = 1 to N number of generators do
     Pi = Pi * α
  For i=1 to N do
If α > 1 and Pi > Pimax then do
     Pi = Pimax
If α≤1 then do
     If Pi < Pimin and i is a generator not available or
      available then do
        Pi = 0;
   If Pi < Pimin and i is a generator in working then
do
   Pi = Pimin;
Until Abs (PD - total power ) /PD< 0.01;
end;
```

Algorithm. 1 procedure of correction: By this algorithm, we create an initial population which satisfy the constraint of minimum and maximum power and that of the balance load.

The fitness function: In this study the goal is to minimize the objective Function (F) given by Eq. 1. The genetic program derived in this research has the option of either minimizing or maximizing the fitness function supplied to it. If the minimization option is chosen, the fitness function is then directly equal to the objective Function (F). However, if the maximization option is selected, it is therefore necessary to map the objective Function (F) into
Fitness Function (FF). The fitness function adopted is:

$$FF = 10^8/F \quad (6)$$

The three basic operators associated with the Genetic Algorithm are reproduction, crossover and mutation.

Reproduction and crossover: The reproduction process creates a new population from the old one. A set of parents are selected and copied according to the probability determined by a parent selection technique. The parent selection can be implemented in a variety of ways.

In this study, a modified roulette wheel selection technique is used. The roulette wheel is biased with the fitness of each string, thus more highly-fitted strings receive a higher number of copies in the next generation. Since we have adopted a real representation of individual, an arithmetic crossover seems to be efficient, we have chosen to level-head with the fitness in order to obtain individual which approach to the best parent.

After The creation of child, we correct it using algorithm.1 to obtain an individual which satisfy the constraint of minimum and maximum and that of balance load.

Mutation: Mutation is performed by randomly selecting a power value and changing it using the following equation.

$$P = Pmin + \beta\,(Pmax - Pmin)$$
$$\beta \in [0\ 1]$$

After creation of child, the algorithm 1 of correction is applied.

Probabilities of mutation and crossover: Like other stochastic methods, Genetic Algorithm has a number of parameters that must be selected, i.e. size of population, Probability of crossover (Pc) and Probability of mutation (Pm).

We have studied the influence of the probability of mutation and crossover to the convergence of the problem.

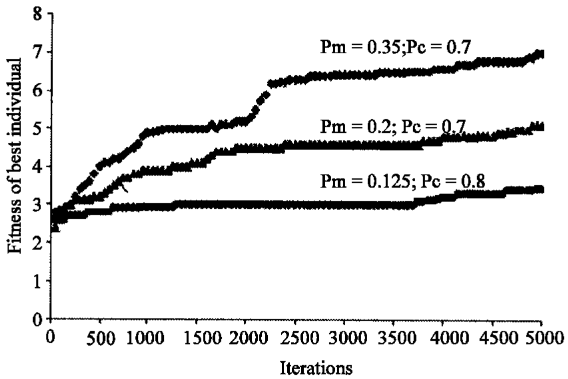

Fig. 3: Variation of fitness of best individuals as function of Probability of Mutation (Pm) and crossover (Pc)

Table 1: Experimentation results and comparaison of genetic algorithm and convential method of the STEG

		Consumption of fuel 10^3 kg	
		Conventional method	Genetic algrithm
Rades	TV1	7627	8106
	TV2	7758	8249
	TV3	7437	8810
	TV4	6363	4887
Sousse	CC	7884	1542
	TV1	7914	8880
	TV2	6403	7727
Goulette	TV2	1670	1200
	TV4	1517	1072
Gannouche	TV1	2039	1093
	TV2	2055	1200
	TG2	9548	126
Bouchema	TG(1,2,3)	8858	3722
B'Mcherga	TG(1,2)	6493	248
Korba	TG1	1058	237
	TG2	1758	155
Kasserine	TG1	1427	354
	TG2	1410	302
Sfax	TG1	1354	159
	TG2	1245	159
Total consumption (10^9 kg)		91.818	58.228

TV: Steam generator unit; TG: Gaz generator unit; CC: Cycle Combine unit

In Fig. 3, we represent the variation of the Fitness of best individuals with iterations as function of Probability of mutation (Pm) and crossover (Pc), we consider three combination, the best one is that of (Pc = 0,7; Pm = 0,35).

In Genetic Algorithm, crossover combines best individuals and gives a new individual which contain the best characteristic of parents, however, mutation improves diversity of the population.

If we eliminate the operation of mutation, we converge rapidly to a local optimum and we did not explore all feasibles solutions, thus a well studied combination of probability of crossover and mutation allows the obtention of best result.

SIMULATION RESULTS

The proposed method is applied to the electric system of the STEG. The example system contains a set of 26 generators (combined cycle, 10 steam generators and 15 gaz generators).

The system data and results are given in Table 1.

The result about fuel consumption expressed in Kg obtained from the proposed method is compared with the results of the classical method applied in the STEG (Rahmouni, 1997).

The application of genetic Algorithm to this case permits a reduction of the fuel consumption by about 37%.

CONCLUSION

This study introduces a new solution approach based on genetic algorithms to the problem of power economic dispatch of the Société Tunisienne d'Électricité et du Gaz. The problem is formulated as a constrained optimization problem.

The algorithm permits the application of Genetic algorithm to an initial feasible individual.

The developed genetics-based program is able to handle successfully such a constrained problem. The program also has the option of either minimizing or maximizing the optimization objective function. The algorithm is implemented and tested.

Results obtained show that the technique can be considered as a fast reliable alternative way to the conventional techniques used in this area and it permits a reduction of the consumption of fuels of by 37%.

REFERENCES

Arroyo, J.M. and A.J. Conejo, 2002. A Parallel Repair Genetic Algorithm to Solve the Unit Commitment Problem IEEE. Tans. Power Sys., 17: 1216-1224.

Gil, E. and J. Bustos, 2002, Short-Term Hydrothermal Generation Scheduling Model Using a Genetic Algorithm, IEEE. Trans. Power Sys., 17: 1256-1263.

Ghose, T., S.K. Goswami and S. Kbssu, 1999. Solving capacitor placement problem in distribution systems using geetic algorithms, Elec. Machines and Power Sys., 27: 429-441.

Iba, K., 1994. Reactive power optimization by genetic algorithm, IEEE. Trans. Power Sys., 9: 2654-2665.

Michalewicz, Z., 1995. A Survey of Constraint Handling Echniques in Evolutionary Computation Methods, in Proc. 4th Ann. Conf. Evolutionary Programming, MIT Press, Cambridge, pp: 135-155.

Michalewicz, Z., 1996. Evolutionary algorithms for constrained parameter optimization problems, Evolutionary Computation, 4: 1-32.

Osman, M.S., M.A. Abo-Sinna and A.A. Mousa, 2004. A solution to the optimal power flow using genetic algorithm, Applied Mathematics and Compu., 155: 391-405.

Rahmouni, H., 1997. De l'Optimisation de la consommation en Combustible Durant le Creux. Rapport interne de Stage, Département des Techniques de Production de l'Electricité.

Su, C.T. and C.L. Chiang, 2004. An incorporated algorithm for combined heat and power economic dispatch, Elec. Power Sys. Res., 69: 187-195.

Xiangping, M., Z. Huaguang and T.Wanyu, 2000. A hybrid method of GA and BP for short-term economic dispatch of hydrothermal power systems, Math. Comp. Simulation, 151: 341-348.

Youssef, H.K. and K.M. El-Naggar, 2000. Genetic based algorithm for security constrained power system economic dispatch, Electric Power Sys. Res., 53: 47-51.