Congestion Relieving in Electric Power Network by Rescheduling of Generator using Bacteria Foraging Algorithm

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Abstract— In a deregulated electricity market, when congestion occurs in a transmission line it violates system security and increase system cost. Transmission lines congestion is one of the technical problems which appear particularly in the deregulated environment. In a deregulated era, one of the important tasks of ISO is congestion free power system. Generator rescheduling is one of the techniques adopted by ISO to mitigate transmission congestion in a deregulated electricity market. Present paper proposed A Bacteria Foraging Algorithm based generator rescheduling for congestion management problem. The BFA is a new metaheuristic approach inspired by intelligent foraging behaviour of optimization is used for generators. The proposed algorithm is applied on IEEE 30 Bus System.

Key words: Congestion Management, Bacterial Foraging Algorithm, Security Constrains, Optimal Solution

I. Introduction

Regulated power sector can be described as integrated utility where generation, transmission and distribution are coming under single organization like India. A single organization is very difficult to manage overall transaction from generation to consumption and also reduces the efficiency.

To improve the efficiency, the modem electric utilities are introducing privatization in their sectors. This call for separation of the generation, transmission and distribution function i.e. Generation Companies (GENCOs), Transmission Companies (TRANSCOs) and Distribution Companies (DISCOs). The reasons for the reforms are many and varied both for developing and developed countries [1]. To maintain the coordination between GENCOs, TRANSCOs and DISCOs there will be an operator in restructured power system, he is Independent System Operator (ISO).

In restructured power system, there will be possible for congestion in transmission line. Various cases for congestion like i) Uniform line loading ii) Line outage iii) Bilateral and multilateral transactions between source and loads. These transactions are modelled as either bilateral transaction.

Some literature intended to present reducing the number of participating generators in rescheduling. It also optimally reschedules their real power output while managing congestion at minimum rescheduling cost. Congestion Management (CM) can be carried out by rescheduling of real power generation based on cluster/zone method utilizing Transmission Congestion

Distribution Factors (TCDFs) [1]. In another paper generator rescheduling is done by using Genetic algorithm for minimizing cost of rescheduling [2]. Generation sensitivity factor (GSF) has been used to identify the generators which affect more on congested lines. The optimal rescheduling of generators using particle swarm optimization is used by some researcher [3]. The method of particle swarm optimization is an evolutionary algorithm and was first introduced by Kennedy and Eberhart in 1995 [4].Another paper [5] mainly intended to present a technique for reducing the number of participating generators in rescheduling.

In addition it also optimally reschedules their real power outputs while managing congestion at minimum rescheduling cost by using particle swarm optimization algorithm. The Fitness Distant Ratio Particle Swarm optimization (FDRPSO) based optimal power flow is introduced for Congestion Management problem first time in [6] to solve nonlinear program like congestion in restructured electric power network.

The optimal power flow problem based on Bacterial Foraging Algorithm is proposed in [7]. This method is used to relieve the congestion, improves the loadability and voltage stability, and reduces the line losses and cost of production by controlling the power flow in the network. The proposed method is demonstrated on IEEE 30 bus system and the results are to be compared with other optimization methods. Bacterial Foraging Algorithm (BFA) mimics the foraging strategy of E. coli bacteria which try to maximize the energy intake per unit time. “Foraging strategies” is the methods for locating, handling, and ingesting food. After many generations, poor foraging strategies are either eliminated or shaped into good ones. . Logically, such evolutionary principles have led scientists in the field of “foraging theory” to hypothesize that it is appropriate to model the activity of foraging as an optimization process [8]. A paper [9] presents some modification to the original algorithm that simplifies the algorithm structure which improves the performance.

The problem of premature convergence is resolved in “A Novel Bacterial Foraging Optimizer with Linear Decreasing Chemotaxis Step” [10]. The performance comparisons indicated that this proposed method is capable of alleviating the problems of premature convergence in BFO.

II. Problem Formulation

The objective of optimal power flow is to identify the control variables which minimize the objective function. This is formulated mathematically as follows:

A. *Problem Objectives:*

In this paper following objective are considered:

1) *Minimization of System Power Losses:*

Here minimization of system real power losses, Ploss (MW) is considered as one of the objective function. Reactive power control variables are adjusted at their optimal settings which can minimize the system real power losses. The power loss function is as follows [9]

$$f = Ploss = \sum_{k=1}^{NL} g_k \left[|V_i|^2 + |V_j|^2 - 2|V_i||V_j|\cos(\delta_i - \delta_j) \right] ----(1)$$

It is the loss formula at kth line connected between ith and jth bus. Here, NL is the number of transmission lines; gk is the conductance of the kth line; Vi and Vj are the voltage magnitude at bus end i and j of the line, respectively, and δi and δj are the voltage phase angles at the end buses i and j.

2) *Minimization of Fuel Cost with Real Power Output:*

The fuel cost of each fossil fuel fired generator can be expressed as a single quadratic function but the cost function has discontinuities corresponding to change of fuels [5]. Therefore, it is more appropriate to represent the cost function with piecewise quadratic functions. The total fuel cost in terms of real power output can be expressed as [13]:

$$f(Pg) = \sum_{i=1}^{NG} C_i$$

$$f(Pg) = \sum_{i=1}^{NG} a_i Pg_i^2 + b_i Pg_i + c_i \$/h ---(2)$$

B. System Constraints:

In this paper following equality and inequality constraints are considered:

1) *Equality Constraints:*

$$\sum_{i=1}^{NG} Pg_i - \sum_{i=1}^{NB} Pd_i - Ploss = 0 ---(3)$$

$$Pg - Pd - Vi\sum_{j=1}^{NB} Vj[Gij\cos(\delta i - \delta j) + Bij\sin(\delta i - \delta j)] - (4)$$

Above equations are the power balance equation and power flow equation. Where i=1,. . .,NB; NB is the number of buses, Pg is the active power generated, Pd is the active power load, Gij and Bij are the transfer conductance and susceptance between bus i and bus j, respectively.

2) *Inequality Constraints:*

1) Generator Constraints: Generator voltages are varied in between their upper and lower bounds:

$$Vg_i^{\min} \le Vg_i \le Vg_i^{\max} --(5)(i = 1, 2...NG)$$

2) Transformer Constraints: transformer tap-setting are bounds as follows:

$$T_i^{\min} \le T_i \le T_i^{\max} --(6)(i = 1, 2....NT)$$

III. BACTERIAL FORAGING ALGORITHM

Recently, bacterial foraging algorithm (BFA) has emerged as a powerful technique for the solving optimization problems. BFA mimics the foraging strategy of E. coli bacteria which try to maximize the energy intake per unit time. From the very early days it has drawn attention of researchers due to its effectiveness in the optimization domain. To improve its performance, a large number of modifications have already been undertaken. The foraging strategy of Escherichia coli bacteria present in human intestine can be explained by four processes, namely chemotaxis, swarming, reproduction, and elimination-dispersal [14].

A. Chemotaxis:

Chemotaxis process is the characteristics of movement of bacteria in search of food and consists of two processes namely swimming and tumbling. A bacterium is said to be swimming if it moves in a predefined direction, and tumbling if moving in an altogether different direction.

B. Swarming:

An interesting group behaviour has been observed where a group of E.coli cells arrange themselves in a traveling ring by moving up the nutrient gradient when placed amidst a semisolid matrix with a single nutrient chemo effecter. The cells, when stimulated by a high level of succinct, release an attractant aspirate, which helps them to aggregate into groups and thus move as concentric patterns of swarms with high bacterial density. The cell-to-cell signalling in E.coli swarm may be represented by the following function.

C. Reproduction:

In this step, population members who have had sufficient nutrients will reproduce and the least healthy bacteria will die. The healthier half of the population replaces with the other half of bacteria which gets eliminated, owing to their poorer foraging abilities. This makes the population of bacteria constant in the evolution process.

D. Elimination and Dispersal:

Gradual or sudden changes in the local environment where a bacterium population lives may occur due to various reasons e.g. a significant local rise of temperature may kill a group of bacteria that are currently in a region with a high concentration of nutrient gradients. Events can take place in such a fashion that all the bacteria in a region are killed or a group is dispersed into a new location. To simulate this phenomenon in BFOA some bacteria are liquidated at random with a very small probability while the new replacements are randomly initialized over the search space.

E. Congestion due to Contingency:

In this paper IEEE 30 standard bus system is used which contains 5 generator buses, 1 slack bus and 24 load buses. The algorithm is tested for various demand and give the economic generator scheduling for the same.

In healthy condition all line flows are within limits and none of the lines are overloaded or congested.

For study purpose and achieve the goal we consider one contingency as discussed in [1].

Lines between buses	**Line flows (MW)**	**Max line limits (MW)**
1-2	125.49947	130
2-6	60.57198	65

An outage of line 4-6 causes congestion on lines 1-2 and line 2-6. . In the line 1-2, line flow is 131.59092 MW against its limit of 130 MW and in the line 2-6, it is 70.3005 MW against its limit of 65 MW.

Lines between buses	Line flows (MW)	Max line limits (MW)	More MW than Max line limit
1-2	131.59092	130	1.59092
2-6	70.30050	65	5.30050

IV. RESULTS AND DISCUSSION

The Bacterial Foraging Algorithm for congestion management problem has been implemented using Matlab-10a programming language. The performances of the proposed method were carried out on the IEEE 30-bus test system. The restructured electrical network is made in the case of bilateral transaction in the existing network.

S. No.	Parameters	Un-optimized Values	Optimized Values by BFA
1	Pg1	166.42	175.84
2	Pg2	41.22	40.76
3	Pg5	24.65	23.51
4	Pg8	20.00	22.47
5	Pg11	20.00	15.58
6	Pg13	20.00	15.99
7	Power loss (MW)	10.13	10.78
8	Total Gen. (MW)	292.29	294.15
9	Total Cost ($/h.)	888.05	856.05

BFA gives the optimized value of active power of the generators. As we can see in table

We can see dreom the result that total cost decreased by using BFA. BFA also give optimized generator scheduling.

V. CONCLUSION

This paper deals with, minimization of the cost of real power generation by optimal allocation of generating units to load demand subjected to equality and inequality constraints. Here Bacteria Foraging Algorithm is used to find out optimal active power generation that will reduce the cost subjected to equality and inequality constrain.

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