Generator Rescheduling For Congestion Management By Genetic Algorithm

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ABSTRACT

In power system operation, congestion management has become more complicated with the increase of system complexity in deregulated environment. That is why, in present scenario of power system congestion management is a complex task of an independent system operator (ISO). In this paper, generator rescheduling is used as a congestion management technique. Congestion Management is one of the important task in day to day power system. Congestion occurs when usage of transmission line crosses the maximum limit. Generator Rescheduling is one of the best techniques to reduce Congestion. The proposed paper uses the Genetic Algorithm for rescheduling of generators alleviation of congestion. The Genetic Algorithm is one of the optimization technique which is based on natures of the chromosomes. The main important feature of the purposed method is to get high accurate solution with respect to the conventional method.

Keyword: - *Genetic Algorithm, Congestion Management, Generator Rescheduling.*

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1. INTRODUCTION

Power System congestion management issue is becoming more complex day by day as number of consumer is increasing. Transmission lines play as an interconnected medium between suppliers and consumers and maintain its thermal limits. Violation of thermal limits results in congestion in the lines which may further destroy some other lines or entire system. So, proper techniques must be taken to avoid congestion. Various methods are available for limiting the congestion are operating FACTS devices, load shedding, generator rescheduling, use of phase shifting transformer, and line switching So, one of the technique called generator rescheduling is adopted in present work to manage transmission congestion. With increasing computer speed, researcher are increasingly applying artificial and computational intelligence technique in power system problem. This method offer several advantages over traditional numerical methods. Genetic algorithm one of the best artificial intelligence technique for congestion management in transmission line. A genetic algorithm mimics Darwin's evolution process by implementing "survival of the fittest" strategy. GA solves the linear and nonlinear problems by exploring all regions of the search space and exponentially exploiting promising areas through selection, crossover, and mutation operations. In this study, GA solution of the load flow problem is presented in order to minimize the total real and reactive power mismatches at various buses.

The load flow studies are the backbone of the design of a power system. They are the means by which the future operation of the system is known ahead of time. The load flow problem is one of the basic problems in the power system engineering, and can be expressed as a set of non-linear simultaneous algebraic equations, and thus it is to have multiple solutions [1]. A load flow study is the determination of voltage, current, power, and power factor or reactive power at various points in an electrical network under existing or contemplated conditions of normal operation, so power flow calculations provide power flows and voltages for a specified power system subject to the regulating capability of generators, condensers, and tap changing under load transformers as well as specified net interchange between individual operating systems. This information is essential for the continuous evaluation of the current performance of a power system and for analysing the effectiveness of alternative plans for system expansion to meet increased load demand. The continual expansion of the demand for electrical energy due to the growth of industries, commercial centers , and residential sections requires never-ending additions to existing power systems. The systems engineer must decide what components must be added to the system many years before they are put into operation and he does this by means of power flow studies. The load flow solution usually provides additional information, e.g. losses [2]. The load flow is the most frequently carried out study by power utilities and is required to be performed at almost all the stages of power system planning, optimization, operation, control, and contingency analysis.

2. PROBLEM FORMULATION

The idea of congestion management is implemented by increasing or decreasing the active power output of the generators. The amount of rescheduling required by the selected generator is obtained by solving the following optimization problem:

$$\min \ f(x) = (p_k^{\max} - p_k^i) + \sum_{i=1}^{m} \Delta p_g \qquad (1)$$

where,

$p_k^{\max}$ is maximum amount of power at line

p_k^i is the power at line k

Δp_g is the change in real power generation

Thus the objective function is subjected to equality, security constraints and voltage constraints.

2.1 Equality constraints-

$$P_{GK} - P_{DK} = \sum_{J=1}^{NB} V_j V_k Y_{kj} \cos(\delta_k - \delta_j - \theta_{kj}); k \forall NB \qquad (2)$$

$$Q_{GK} - Q_{DK} = \sum_{J=1}^{NB} V_j V_k Y_{kj} \sin(\delta_k - \delta_j - \theta_{kj}); k \forall NB \qquad (3)$$

$$P_{Dj} = P_{Dj}^c ; j = 1,2, Nd \qquad (4)$$

where p_{Dj}^{c} is the active power consumed by demand j as determined by the market clearing procedure, p_{Gk} is the real power generation of generator k and p_{Dj} is the real power consumption of demand j after congestion management. Q_{Gk} and Q_{dK} are the reactive power generation and reactive power demand at kth bus respectively; V_j and V_k are the voltage magnitude of bus j and k respectively; δ_j and δ_k are the angles of bus voltage j and k respectively; Y_{kj} and θ_{kj} are the magnitude and angle of bus admittance matrix. N_g , N_b and NB are the number of generators ,loads and buses respectively.

Constraints (2) and (3) are the real and reactive power balances in each bus respectively. Constraint (4) is the final powers.

2.2 Inequality Constraints:

The limits of the loading of the equipments and the requirements of operation usually consist of the inequality constraints of the problem.

$$P_{Gk}^{\min} <= P_{Gk} <= P_{Gk}^{\max}, k \in N_g \qquad (5)$$

$$Q_{Gk}^{\min} <= Q_{Gk} <= Q_{Gk}^{\max}, k \in N_g \qquad (6)$$

$$\Delta P_{Gk}^{+} >= 0; \Delta P_{Gk}^{-} >= 0; \qquad (7)$$

Constraints (5) and (6) are the upper and lower limits of the real and reactive power of generators. Constraint (7) shows that the incremental and decremented powers are positive.

2.3 Security constraints:

For the safe operation of the transmission line loading factor L_{ij} is kept within the upper limit as follows:

$$L_{ij} = (P_{ij} / P_{ij}^{\max}) <= 1 \qquad (8)$$

Where P_{ij} and $p_{ij}^{\max}$ were the real power flow of the line i-j and maximum flow limit of line i-j.

2.4 Voltage Constraints:

The load bus voltage level at the load bus is maintained within upper and lower bounds which is expressed as:

$$V_n^{\min} <= V_n <= V_n^{\max}, \forall n \in Nd \qquad (9)$$

2.5 Severity Index:

For any power system, unexpected outage of the lines or transformers occurs due to faults or other disturbances. These are referred as congestion which causes overloading of lines or transformers. The stress on power system due to congestion may be expressed as follows:

$$SI = \sum_{k \in L0} (P_k / P_k^{\max}) \Lambda 2m \qquad (10)$$

where L_0 is the set of overloaded lines, p_k is the real power in the branch k , $p_k^{\max}$ is the maximum flow limit of the kth branch, and m is the weighting coefficient.

The value of m is chosen as 1 to decrease the masking effect. For the safe system value of SI is zero. The greater value the more severe congestion would be.

3. IEEE 30 BUS SYSTEM

The proposed paper discusses the concept of generator rescheduling for the Congestion Management using GA optimization technique has been illustrated on IEEE 30 bus system[9].The 30 bus system is the representation of 6 generators,4 load buses and 41Transmission lines. In the study of the congestion management analysis is conducted for base case generations and also the demand in order to find the most severe lines. For the each line outages Gauss Siedel load flow method had been employed for identifying the overload cases. Among all the lines line 1-2 is identified to be the most severe one and the severity index yields to be greater than 1.

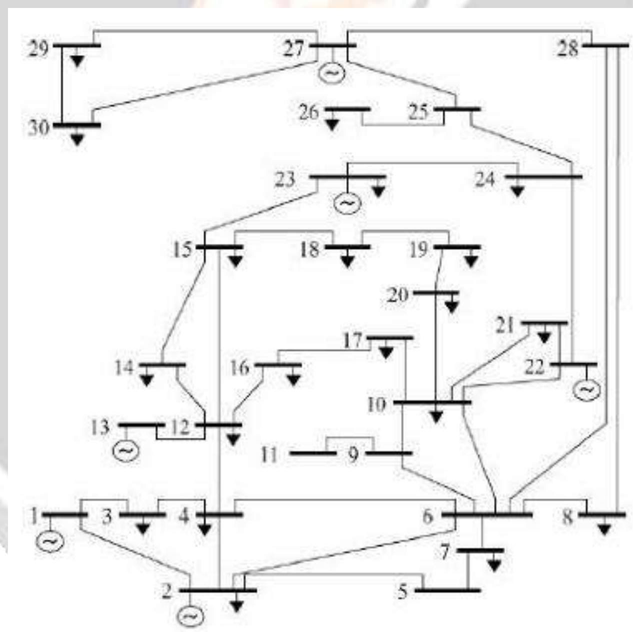

Fig.1: IEEE 30 bus system

4. GENETIC ALGORITHM

Genetic algorithms (GAs) are adaptive methods which may be used to solve search and optimization problems. 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, if they have been suitably encoded [3].Genetic algorithms work with a “population of individuals”, each representing a possible solution to a given problem. Each individual is assigned a “fitness score” according to how good a solution to the problem it is. The highly-fit individuals are given opportunities to “reproduce”, by “cross breeding” with other individuals 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 get selected for reproduction, and so "die out". 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. This new generation contains a higher proportion of the characteristics possessed by the good members of the previous generation. In this way, over many generations, good characteristics are spread throughout the population. By favouring the mating of the more fit individuals, the most promising areas of the search space are explored. If the genetic algorithm has been designed well, the population will converge to an optimal solution to the problem. There are some differences between genetic algorithms and traditional searching algorithms (such as numerical techniques).

They could be summarized as follows [4]:

- The algorithms work with a population of strings, searching many peaks in parallel, as opposed to a single point.
- Genetic algorithms work directly with strings of characters representing the parameters set, not the parameters themselves.
- Genetic algorithms use probabilistic transition rules instead of deterministic rules.
- Genetic algorithms use objective function information instead of derivatives or other auxiliary knowledge (convexity, modality, continuity, differentiability).
- Genetic algorithms have the potential to find solutions in many different areas of the search space simultaneously.

5. GENETIC ALGORITHM IMPLIMENTATION

A simple genetic algorithm is an iterative procedure, which maintains a constant size population of candidate solutions. During each iteration step (generation), three genetic operators (reproduction, crossover, and mutation) are performing to generate new populations (offspring), and the chromosomes of the new populations are evaluated via the value of the fitness which is related to cost function. Based on these genetic operators and the evaluations, the better new populations of candidate solutions are performed [4]. With the above description, the three steps in executing the genetic algorithm operating on fixed-length character strings are as follows:

1. Randomly create an initial population of individual fixed-length character strings.

2. Iteratively perform the following sub steps on the population of strings until the termination criterion has been satisfied:

A. Assign a fitness value to each individual in the population using the fitness measure.

B. Create a new population of strings by applying the following three genetic operations. The genetic operations are applied to individual string(s) in the population chosen with a probability based on fitness.

i. Reproduce an existing individual string by copying it into the new population.

ii. Create two new strings from two existing strings by genetically recombining substrings using the crossover operation at a randomly chosen crossover point.

iii. Create a new string from an existing string by randomly mutating the character at one randomly chosen position in the string.

3. The string that is identified by the method of result designation (e.g. the best-so-far individual) is designated as the result of the genetic algorithm for the run. This result may represent a solution (or an approximate solution) to the problem.

Now, we'll discuss briefly each step of the implementation of the genetic algorithm:

5.1 Initialization Of Population

In the genetic algorithm, populations of chromosomes are created randomly by generating the required number of individuals using a random number generator that uniformly distributes numbers in the desired range. The extended random initialization is a variation whereby a number of random initializations are tried for each individual and the one with the best performance is chosen for the initial population. Other users of genetic algorithms have seeded the initial population with some individuals that are known to be in the vicinity of the global optimum. This approach is only applicable if the nature of the problem is well understood beforehand or if the genetic algorithm is used in conjunction with knowledge based system [5].

5.2 Fitness Function

The objective function is used to provide a measure of how individuals have performed in the problem domain. In the case of a minimization problem, the mostly fit individuals will have the lowest numerical value of the associated objective function. This raw measure of fitness is usually only used as an intermediate stage in determining the relative performance of individuals in a genetic algorithm. Another function is the fitness function, is normally used to transform the objective function value into a measure of relative fitness [6].

5.3 Selection, Crossover And Mutation

The selection, or competition, is a stochastic process in which the chance of an individual surviving is proportional to its adaptation level. The adaptation is measured by the phenotype (search point, solution) evolution, that is, the characteristics presented by an individual in the problem environment (search space). The genetic algorithm, through selection, determines which individuals will go to the reproduction phase. There are several selection methods, where the fittest individuals from each generation are preferentially chosen for reproduction . By mutation, individuals are randomly altered. These variations (mutation steps) are mostly small. They will be applied to the variables of the individuals with a low probability (mutation probability or mutation rate). Normally, offspring are mutated after being created by recombination [7]. In this process, randomly selected bits of randomly selected strings are changed from (**0**) to (**1**) and vice versa. This process occurs according to pre-specified probability. Usually, less than 5% of bits are changed in this process. Mutation process is used to escape from probable local optimum [8].

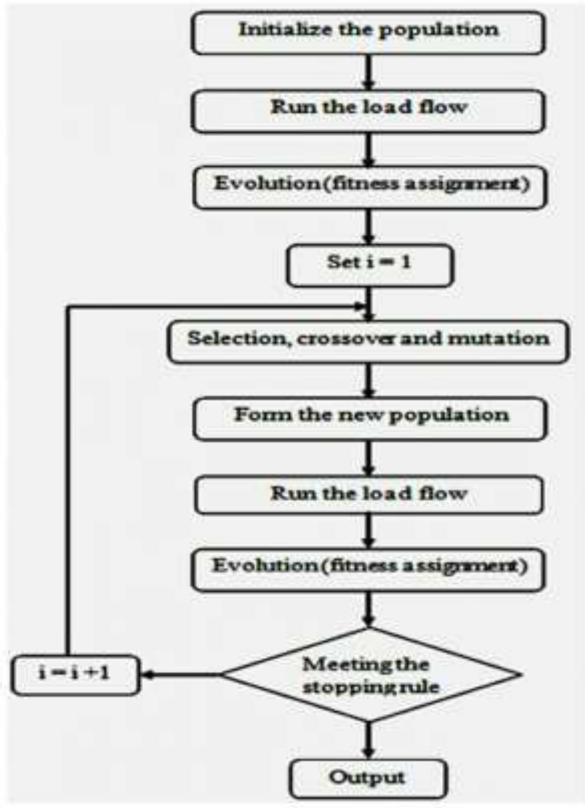

Fig.2: GA flowchart for congestion management

6. RESULTS

The proposed Genetic Algorithm is tested for the three cases. The Genetic Algorithm parameters were:

Cross over fraction:0.8.
Elite count:1
Generations:100
Hybrid function:[]
Migration interval:20
Migration fraction:0.2
Population type

By using genetic algorithm method number of cases for generator rescheduling in order to solve the congestion problem are given below.

Case1:

The load at bus 10 is increased by 90% from the base case values from (5.8+j2.0)MVA to (11.02+3.8j)MVA .Due to the Breakage of the line 1-2 it results in the overloading on two lines 1-3 and 3-4 respectively .Determine active and reactive power flows through line 1-3 and 3-4.also line losses only from 1-3 and 3-4.

Table 1: Results of genetic algorithm method

FROM LINE	TO LINE	MW	MVAR	MVA	MW	MVAR
1	3	125.042	2.736	125.072	6.300	21.394
3	4	116.342	19.859	118.025	1.761	4.188

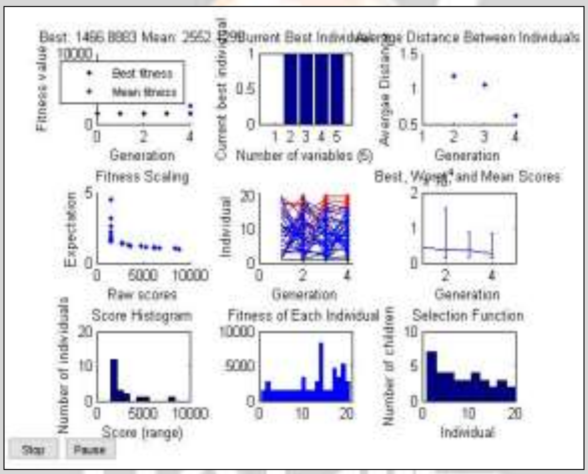

Fig.3: performance characteristics of load at bus 10 increased by 90% from the base values with line 1-2out

Case2:

The load at bus 20 is increased by 40%from the base case values from (2.2+j0.7)MVA to (3.08+0.98j)MVA .Due to the Breakage of the line 1-2 it results in the overloading on two lines 1-3 and 3-4 respectively .Determine active and reactive power flows through line 1-3 and 3-4.also line losses only from 1-3 and 3-4.

Table 2: Results of genetic algorithm method

FROM LINE	TO LINE	MW	MVAR	MVA	MW	MVAR
1	3	129.713	2.989	129.747	6.780	23.363
3	4	120.533	21.57	122.449	1.898	4.581

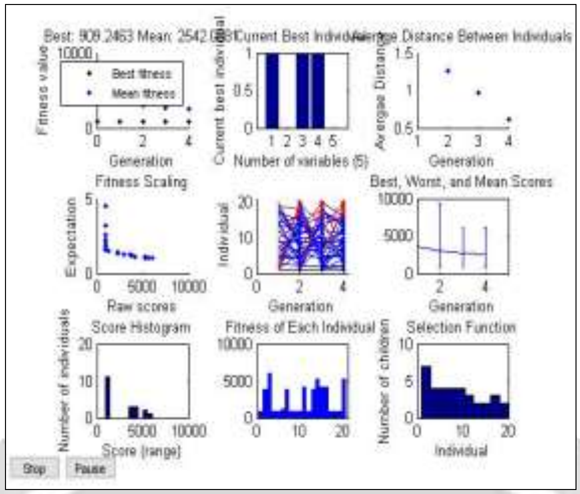

Fig. 4: performance characteristics of load at bus 20 increased by 40% from the base values with line 1-2out

Case3:

The load at bus 17 is increased by 60% from the base case values from (9.0+j5.8)MVA to (14.4+j9.28)MVA .Due to the Breakage of the line 1-2 it results in the overloading on two lines 1-3 and 3-4 respectively .Determine active and reactive power flows through line 1-3 and 3-4.also line losses only from 1-3 and 3-4.

Table 3: Results of genetic algorithm method

FROM LINE	TO LINE	MW	MVAR	MVA	MW	MVAR
1	3	129.713	2.989	129.747	6.780	23.363
3	4	120.533	21.573	122.449	1.898	4.581

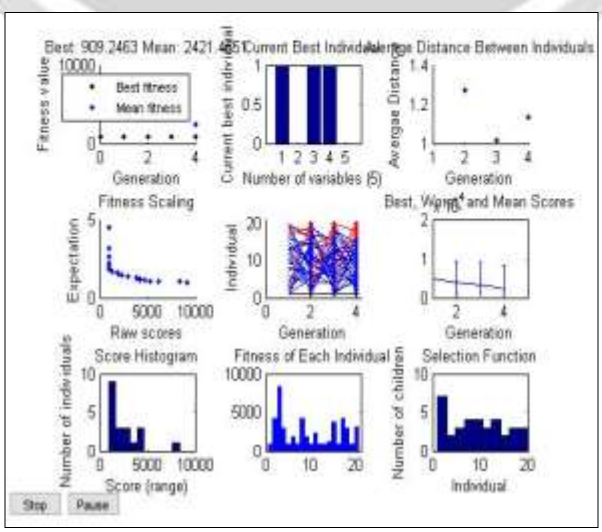

Fig..5: performance characteristics of load at bus 17 increased by 60% from the base values with line 1-2out

After load flow analysis by using generator rescheduling method we observed that, this method gives entire losses due to congestion as well as solution to solve congestion problem. It gives generator rescheduling values almost accurately.

7. CONCLUSIONS

For the efficient operation of the power system possible methods of congestion management need to know. Here the rescheduling of generator active power has been adopted for the congestion management. Hence the GA is chosen as the optimization technique to find the amount of rescheduled power to the congested lines. The results were tested on the IEEE 30 bus system. Hence the Severity Index can be used to find the stress on the power system due to congestion. The fitness value for the individuals are selected and based on that, the problem has solved which has the objective function of minimization of change in real power and is subjected to several constraints. It is also found that GA gives generator rescheduling values almost accurately. Hence the proposed technique completely alleviates overloading of lines for all the cases considered in this study.

8. REFERENCES

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