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Reduction of Transmission Losses based on Optimal Power Flow using Genetic Algorithm

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Abstract

In order to a proper distribution of sources in power network, many methods have been proposed. The importance of this issue and the direct impact on power control in network, it needs a useful inexpensive and exact method. In this paper it is presented an effective and efficient method to power optimized distribution in network based on Genetic Algorithm that simultaneously solves the economic dispatch in power network.the target function in power distribution is composed of three main parameters that has a direct impact on the power grid that consist of transmission loses, voltage profiles and voltage stability.The objective function of Economic Dispatch problem Min cost of fuel Is simply a function of degree2 in plant productivity has been shown Finally, the proposed algorithm on an IEEE 30 buses network implementation and results are presented.

Keywords: *Genetic algorithm, optimal power flow, voltage profile,*

1. Introduction

The opf problem was introduced in the early 1960s by carpentier and has grown into a powerful tool for power system operation and planning. Since 1962 many algorithms have been designed to solve base opf and its derivative problems.(B.Stott and J.LMarinho ,1979)

As the development of power systems and computing technologies opf formulation becomes more and more complicated. Larje- scale and realistic.opf has been widely used in power system operating and planning.

Many optimization techniques have been applied to solve opf problems. Such as mathematical programming (such as linear programming .(B.Stott and J.LMarinho ,1979) quadratic programming(G. F. Raid and L. hasdorf ,1973) dynamic programming (H. W. Dommel and W. F. Tinney,1968) gradient methods and lagrangian relaxation approaches) and modem meta-heuristic methods (such as simulated annealing genetic algorithm(G. Bakirtzis, N. Biskas,2002). Evolutionary algorithms(Jason Yuryevich and Kit Po Wong,1999) adaptive tabu serch particle swarm optimization ect). Some of these methods are successful in locating the optimal solution. But they are usually slow in convergence and require very expensive computational cost. Some other methods may risk being trapped to a local optimum which is the problem of premature convergence.

In this paper and application of genetic algorithm to reduse transmission losses using optimal power flow is proposed. The controllable system quantities are generator power mw controlled voltage magnitude reactive power injection from reactive power sources and transformer tap setting the objective use herein is to minimize the total transmission loss by optimizing the control variables within their limits, therefore no violation on other quantities (e.g. mva flow of transmission lines, load bus voltage magnitude generator mvar) occurs in normal system operating conditions. The proposed method has been tested on ieee 30- bus test power system.

In this paper, the formulation of optimal power flow is explained in section 2 in such a way that the total transmission loss of system is employed to be the system objective. Section 3 provides a brief of genetic algorithm to solve non-linear optimization problems. The ieee 30-bus test power system was challenged and therefore discussed in section 4. The last section provides the conclusions.

2. Optimal power flow problem

The opf problem has grown into a powerful tool for power system operation and planning. In general the optimal power flow problem is a nonlinear optimization problem. It is used to minimize a desired objective function, subject to certain system constraints.(kyung min, sang-hyeon,2010)

The general optimal power flow problem can be expressed as a constrained optimization problem as follow.

Minimize f(x)
Subject to g(x)=0 , equality constraints
H(x)≥0 , in equality constraints

A : Objective function

B : The objective function for total power transmission loss can be expressed as follows.

$$F_1 = F_{Loss} = \sum_{i=1}^{NL}\sum_{j=1}^{NL} g_{i,j}\{V_i^2 + V_J^2 - 2V_iV_j\cos(\delta_i - \delta_j)\}$$

Where ,
V_i = the voltage magnitude bus i.
N_L = the total number of transmission lines.
δ_i = the voltage angle at bus i.
$G_{i,j}$ = the conductance of line i-j.

The second function: Economic Dispatch

$$F_2 = \sum_{i=1}^{NG} C.F_1 = \sum_{i=1}^{NG}(a_i p_{GI}^2 + b_i p_{GI} + C_i)$$

In relation to (2) N_G is Total number of production units P_{GI} is amount of active power generated by unit i, is
The three function : Voltage profile

$$F_2 = \sum_{i\in n}\left|V_i - 1.0^{pu}\right|$$

Voltage profile is parameters that are important. Improve voltage profile can be minimized network load bus voltage deviations from the reference value of 1 pu ensured. Bus loads of the network.

Define the objective functions and constraints According to what was said. we choose The objective function for the problem in the following way.

Objective function 1: Min (F_1=P_{Loss})
Objective function 2: Min (F_2)
Objective function 3: Min ($F_2 = \sum_{i\in n}\left|V_i - 1^{p.u}\right|$)

It has a series of equal and unequal constraints that are expressed in the following way.
Equality Constraint:
Power flow equations are for real power balance eq.

$$P_{Gi} - P_{Di} - \sum_{j=1}^{NB}|V_i||V_j||Y_{i,j}|\cos(\theta_{i,j} - \delta_i + \delta_j)$$

For reactive power balance eq.

$$Q_{Gi} - Q_{Di} - \sum_{j=1}^{NB}|V_i||V_j||Y_{i,j}|\cos(\theta_{i,j} - \delta_i + \delta_j) = 0$$

$$\sum_{i=1}^{N_G} P_{GI} = P_{Loss}^{Total} + \sum_{j=1}^{N_{Loud}} P_{DJ}$$

where:
P_{GI} = the real power generation at bus i.
Q_{GI} = the reactive power generation at bus i.
P_{DI} = the real power demand at bus i.
Q_{DI} = the reactive power demand at bus i.
N_B = the total number of buses.
Inequality Constraint: Variable limitations are

$$V_i^{\min} \le V_i \le V_i^{\max}$$
$$T_i^{\min} \le T_i \le T_i^{\max}$$
$$Q_{comp,i}^{\min} \le Q_{comp,i} \le Q_{comp,i}^{\max}$$
$$P_{G,i}^{\min} \le P_{G,i} \le P_{G,i}^{\max}$$

Where,
$V_i^{min}, V_i^{\max}$: upper and lower limits of voltage magnitude at bus i
$T_i^{\min}, T_i^{\max}$: upper and lower limits of tap position of transformer i.
$Q_{comp,i}^{min}, Q_{comp,i}^{\max}$: upper and lower limits of reactive power source i.
$P_{G,i}^{min}, V_{G,i}^{\max}$: upper and lower limits of power generated by generator i

The penalty function can be formulated as follows.

$$P(x) = F_T + \Omega_P + \Omega_Q + \Omega_C + \Omega_T + \Omega_V + \Omega_G$$

$$\Omega_P = \rho \sum_{i=1}^{N_B}\{P_{G,i} - P_{D,i} - \sum_{j=1}^{N_B}|V_i||V_j||Y_{ij}|\cos(\theta_{i,j} - \delta_i + \delta_j)\}^2$$

$$\Omega_Q = \rho \sum_{i=1}^{N_B}\{Q_{G,i} - Q_{D,i} - \sum_{j=1}^{N_B}|V_i||V_j||Y_{ij}|\cos(\theta_{i,j} - \delta_i + \delta_j)\}^2$$

$$\Omega_C = \rho \sum_{i=1}^{N_C}\{\max(0, Q_{comp,i} - Q_{comp,i}^{max})\}^2 + \rho\sum_{i=1}^{N_C}\{\max(0, Q_{comp,i}^{min} - Q_{comp,i})\}^2$$

$$\Omega_T = \rho \sum_{i=1}^{N_T}\{\max(0, T_i - T_i^{max})\}^2 + \rho\sum_{i=1}^{N_T}\{\max(0, T_i^{min} - T_i)\}^2$$

$$\Omega_V = \rho \sum_{i=1}^{N_B}\{\max(0, V_i - V_i^{max})\}^2 + \rho\sum_{i=1}^{N_B}\{\max(0, V_i^{min} - V_i)\}^2$$

$$\Omega_G = \rho \sum_{i=1}^{N_G}\{\max(0, P_{G,i} - P_{G,i}^{max})\}^2 + \rho\sum_{i=1}^{N_G}\{\max(0, P_{G,i}^{min} - P_{G,i})\}^2$$

Where ,
N_G = the total number of generators.
N_C = the total number of reactive power sources.
N_T = the total number of transformers.

3:genetic algorithm

Genetic algorithm (GA) is a global adaptive search technique based on the mechanics of natural genetics. GA uses a direct analogy of natural behavior . it is applied to optimize existing solutions by using methods based on biological evolution such as the ones presented by Charles Darwin. It has many applications in certain types of problems that yield better results than the commonly used methods without any complicated classical calculation to solve a specific problem with ga. A function known, as fitness function needs to be constructed which allows different possible solutions to be evaluated. The algorithm will then take those solutions and evaluate each one. Deleting that ones that show no promise towards a result but keeping those. Which seem to show some activity towards a working solution. (Z Haibo, Z Lizi , 1998)

In this paper, the above technique is used for genetic optimization algorithm. So that the optimal power flow on the grid paper tests done Losses and expenses down is calculated with respect to the cost function in Appendix A to

The objective function is the same function according to the provisions of the generators is given in Appendix A make up the loss with a genetic algorithm with mutation rate 0.2 Crossover 0.5 with initial population of 12 ,100 iterations the optimal solution we find it.

Following network standard IEEE 30-bus test network as analyzed in this article is taken.

In this Network the only variable controlling is the active power that produced by generators.because the buses are from vltazhsabt of the bus and the reactive power flow is determined by its.

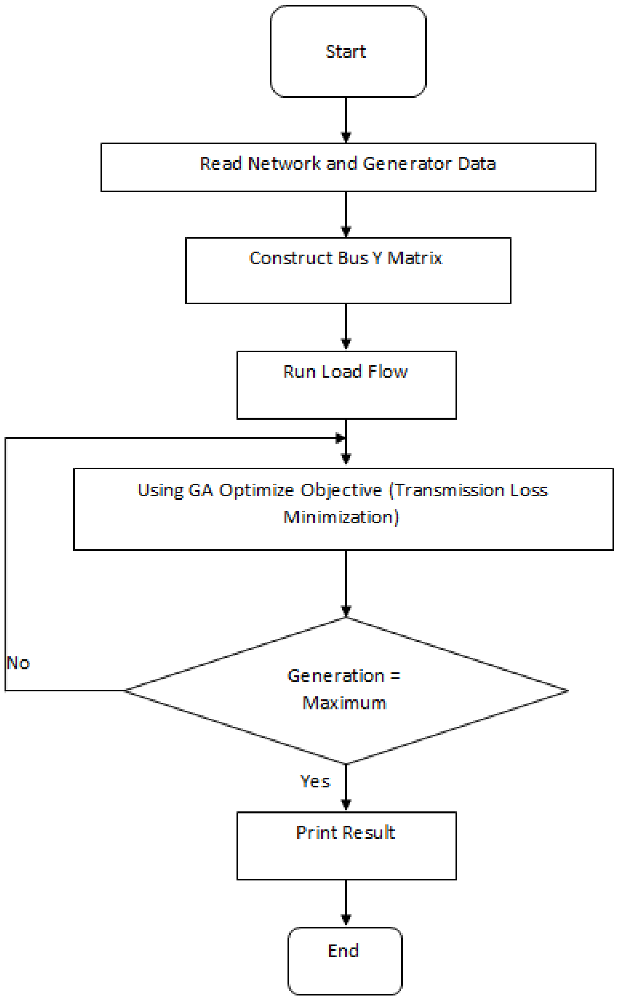

Figure 1 Flowchart of GA application to transmission loss

Table (1) - Results before optimization

The result before optimization	
(MW)generation	293.15
(MW) loud	283.8
(MW) loss	9.347
($/MW) cost	1113.93

On the other hand trans on the network is not with tab changes that could effect on the Net So at each stage of the implementation of Genetic Algorithms earned amount of active power produced by generators and earned losses value

Finally an answer that must comply all constraints it include minimum casualties that the optimum solution for us.

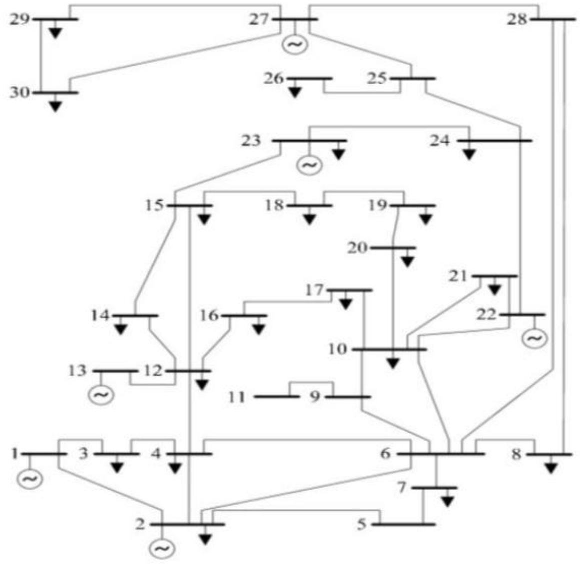

Figure 2 Test Power System

As shown in the table (1) and (2) we see that the losses are reduced significantly.

But in relation to the cost reduction are presented due to unit costs in Annex A. We observe that the costs are reduced significantly.

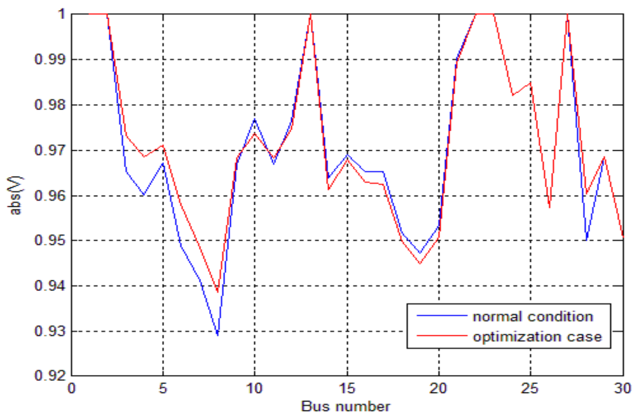

Figure3-Improvement voltage profiles after and before optimization

According to the definition of improvement in voltage profiles we observe the mean deviation Pu in terms of the reference of a more optimized buses is lower than under before the optimized and we reached the main purpose of improving the voltage

Conclusions

The main purpose of this paper was to reduce the losses.That is a the harmful thing for network. In order to do this, we used from optimal loud flow that itself has a direct impact on loses, in other words with optimal load distribution and optimization of loses function by genetic algorithm, we achieved to the main goal of this article, that is loses reduction . also the other purpose of the article, is voltage profile improvement and as resalt of it, transmission lines improvement and the obtained results of algorithm implementation on a standard 30 buses IEEE network have been confirminy of correct proposed algorithm, also.

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Appendix A

Table A1-The upper and lower limit of active generator

Bus Number	Lower Limit	Uper Limit
1	**0**	**80**
2	**0**	**80**
13	**0**	**40**
22	**0**	**50**
23	**0**	**30**
27	**0**	**55**

Table A2-The upper and lower limit of reactive generator

Bus Number	Lower Limit	Uper Limit
1	**-20**	**150**
2	**-20**	**60**
13	**-15**	**44.7**
22	**-15**	**62.5**
23	**-10**	**40**
27	**-15**	**48.7**

Table A3-The upper and lower limit of voltage

Bus Number	Lower Limit	Uper Limit
1	**0.95**	**1.05**
2	**0.95**	**1.1**
13	**0.95**	**1.1**
22	**0.95**	**1.1**
23	**0.95**	**1.1**
27	**0.95**	**1.1**

Table A3- Cost function $C=A+BP+CP^2$

BUS NUMBER	A	B	C
1	**0**	**2**	**0.02**
2	**0**	**1.75**	**0.0175**
13	**0**	**1**	**0.0625**
22	**0**	**3.25**	**0.00834**
23	**0**	**3**	**0.025**
27	**0**	**3**	**0.025**

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