INTERNATIONAL RESEARCH JOURNAL IN ADVANCED ENGINEERING AND TECHNOLOGY (IRJAET) E - ISSN: 2454-4752 P - ISSN : 2454-4744
VOL 2 ISSUE 3 (2016) PAGES 1067-1071
RECEIVED : 03/06/2016. PUBLISHED : 16/06/2016
June 16, 2016

ENERGY SAVING IN IEEE 33 BUS WITH FUEL CELL USING FIREFLY ALGORITHM

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Abstract:
Distributed generation (DG) sources are being more interesting in distribution systems due to the development in demands for electrical energy and to decrease the power disruption in the power system network. By installing DGs in the system, the total power loss can be decreased and voltage profile of the buses can be improved. This paper proposes a new optimization based to determine the optimal location of fuel cell DG in distributed system. The proposed algorithm firefly algorithm (FA) presents the optimal location of fuel cell DG with minimum active power losses. The proposed technique is tested on the Iranian Gas Refinery power distribution model. Experimental results illustrate a considerable reduction in the total power loss in the system and improved voltage profiles of the buses within the frame-work of system operation and security constraints in radial distribution systems.

Keywords: Gas Refinery power distribution model, Distribution Systems; Distributed Generators (DG); Fuel Cell; Optimal placement; Firefly Algorithm (FA).

1. INTRODUCTION

Environmental concern makes the technology move to the utilizing of renewable and clean energy. The electric energy demands are ever increasing, yet with limited transmission lines, many problems for new capacity and steady development in power deregulation and utility reconstructing have all contributed to distributed generation becoming ever more popular. Distributed generation performs as a small-scale electric power source which is connected directly to the distribution network stuff, and makes electric power at a site near to the customers, rather than through lengthy transmission lines spanning from central power stations. Distributed generators capacity scale is ranged from several kilowatts to the 50 megawatts. The main problem in the distributed generators is their high costs but it has low emission of pollution (Mr. Parichay Das and N.N.Jana, 2011). With the liberalization and deregulation in the market, the number and capacity of small to medium scale distributed generators is expected to enhance mainly in the near future (M. H. Nebrir et al., 2006)(J. Yao and D. Popovic, 2004). Fuel cell as a usable DG, power generation has several advantages, like reusability of exhaust heat, low environmental pollution, high efficiency, fuel diversity and modularity. Fuel cells are usually defined by the type of electrolyte they use, resulting in five major types of fuel cells in current technology for utilize in the industry. The Proton Exchange Membrane Fuel Cell (PEMFC) in particular is being rapidly developed as a significant power source in many applications through its low operating temperature, high energy density and rigid yet simple structure. Nonetheless, the fuel cell has its own challenges to meet the demand for high energy efficiency and availability. Despite distributed generators may never replace the central power stations, they can be a proper option when constraints in transmission network prevent economic, or least expensive, supply of energy reaching demand. However, essence and viability of distributed generators at a specific location is affected by technical as well as economic factors. The optimal power flow (OPF) has been developed a long time ago when Carpenter presented a distributed formulation of the economic dispatch problem consisting of voltage and other operating constraints. This formulation was later named the Optimal Power Flow problem (Carpenter J, 1962). OPF programs based on mathematical programming approaches are used daily to solve very large OPF problems. But they are not guaranteed to converge.

2. PROBLEM FORMULATION

The problem is formulated to minimize the power and voltage losses as objective function. Conventional OPF algorithm for cost minimization is improved to establish the demand bids, in addition to the generation bids. Firefly algorithm (FA) is determined as the system optimizer. The generator and customer bids are taken as inputs to OPF. The placement is considered to meet the demand at lower price by varying the dispatch scenario. The problem is formulated to minimize the power and voltage losses as objective function. Conventional OPF algorithm for cost minimization is improved to establish the demand bids, in addition to the generation bids. Firefly algorithm (FA) is determined as the system optimizer. The generator and customer bids are taken as inputs to OPF. The placement is considered to meet the demand at lower price by varying the dispatch scenario. The current domain in the transmission lines can be evaluated by the power flow calculations. Within optimal placement of fuel cell in the system busses and the electrical power injection, current domain decreases in the lines and hence, the power losses decreased in the system. The existing OPF methods have some problems, which contain not only the robustness of optimization approach used, but also the power system modeling. A great deal of classical optimization techniques have been implemented for solving the OPF problems considering a single objective function such as Non-Linear Programming (Alsac O., Stott B., 1974), Quadratic Programming (Grudinin N., 1997)(Aoki K. and Kanezashi M., 1985), Linear Programming(Torres G.L., Quintana V.H., 2000)(Pudjianto and Strbac G., 2002), Newton-based techniques (Aoki K. and Kanezashi M., 1985)(Hong Y.Y. et al., 1993), Sequential unconstrained minimization technique (Rahli M., 1999), Interior point methods (Liu S. et al., 2002) and Parametric method (Almeida K.C., 1994).

3. FIREFLY ALGORITHM

The Firefly Algorithm was developed by Yang (Yang, 2009), and it was modeled based on the idealized behavior of the flashing characteristics of fireflies as below:

- All the fireflies are unisex; therefore one firefly is attracted to other fireflies regardless of their sex.
- Attractiveness is proportional to their radiance as for two flashing fireflies, the one which has less brightness, will move towards the brighter one. The attractiveness is proportional to the brightness and they both lessen as their distance increase. If no firefly is brighter than a specific one, it moves randomly.
- The brightness or light intensity of a firefly is affected or described by the landscape of the fitness function to be optimized.

constraint is met, its influence to is zero. Albeit, when the equality constraint is violated, it is penalized heavily as it increases considerably. It is also true when inequality constraints becomes tight or exactly. It should be illustrated that the generation and the ramp rate limits are similar type of constraints where together define the overall upper/lower generation limits of the units. All these traditional optimization algorithms have definite problems associated with them such as insecure convergence, piecewise quadratic cost approximation and may even fail to converge due to in consider initial conditions for Newton based method. The usual criterion for optimal operation will be the minimization of generation cost if both of active and reactive powers are dispatch-able in an electrical network. If only a reactive power is dispatch-able, then active power loss minimization is frequently the considered objective. Difficulties grow because

Firefly Algorithm
Objective function $f(x), x = (x_1, \cdots, x_d)^T$
Initialize a population of fireflies $x_i (i = 1, 2, \cdots, n)$
Define light absorption coefficient γ
while $(t < MaxGeneration)$
for i = 1: n all n fireflies
for j = 1: i all n fireflies
Light intensity I_i at x_i is determined by $f(x_i)$
if (Ij > Ii)
Move firefly i towards j in all d dimensions
end if
Attractiveness varies with distance r via exp $[-\gamma r^2]$
Evaluate new solutions and update light intensity
end for j
end for i
Rank the fireflies and find the current best
end while

Fig.1. The pseudo code of the firefly algorithm

either the amount of computation required quickly becomes irresoluble as the size of the problem enhances or the constraints violate the required assumptions; that is, differentiability or convexity. In the real world, there is exists often such problems. The evolutionary computation approaches can be designed to solve the described problems. Evolutionary programming technique may provide more rapid and robust convergence on many function optimization problems.

4. SIMULATIONS AND RESULTS

In this section, the proposed technique is utilized on the 24 node Iranian Gas Refinery distribution system to analyze the system performance. The proposed firefly based approach has been used to achieve the optimal locations of DGs for each case separately. For ranking of optimal DG locations, all of the available DGs are taken simultaneously. First of all and for analyzing the results, firefly algorithm has been applied on the Gas Refinery distribution system. To do this, algorithm parameters in two cases (FA1 and FA2) are employed:

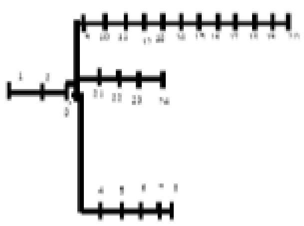

Fig.2. single-line schematic of a part of Iranian Gas Refinery distribution system.

the fuel cell installation in the bus number 11 for the Gas Refinery distribution system with 10MW injection power which the power losses and the related costs are decreased by the fuel cell installation.

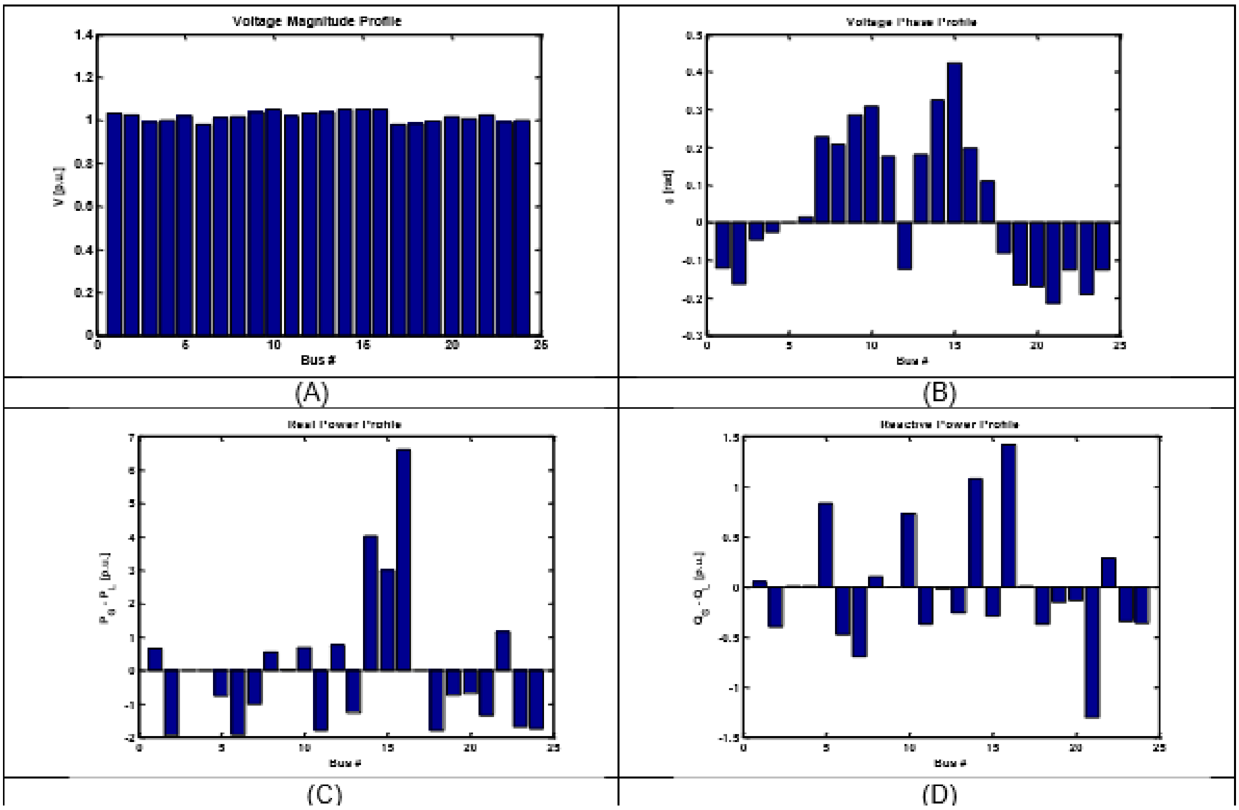

Fig.3. (A) voltage, (B) angle, (C) active power and (D) reactive power profile in the Gas Refinery distribution system without using fuel cell (pu)

For better analyzing the system, voltage domain diagram (pu) and Busses voltage angle (rad) with system active and reactive busses are applied by psat toolbox and the results are shown in below. For example, figure 3 shows the system without fuel cell installation.

CONCLUSION:

In this paper, we proposed a firefly algorithm based methodology to optimal placement of distributed generation (fuel cell in this research) in the Gas Refinery distribution system. This approach is applied and analyzed with two cases: with and without fuel cell allocation. The main step is to optimal placement of DGs which are obtained by using firefly algorithm with an objective of minimizing the cost of power and voltage losses. As it is presented, DGs are low power generation power plants which are installed near the consumers. Environmental concern, high charge, less performance, etc. in the large scale power plants makes DGs as an interesting category in generating the energy. The results clearly indicate the overall ranking of bus places and the type of energy sources to be placed there. In this planning work, fuel-cell energy has been used. Experiment results show a proper distribution generation for the proposed method.

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