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Optimal Power Flow Using Grass Hopper Optimization Algorithm for Generator Fuel Cost and Voltage Profile

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***Abstract*—** In this paper, optimal power flow (OPF) using grass hopper optimization algorithm (GOA) is addressed. OPF is a basic tool for economical and secure operation of power system. Here, the generator fuel cost and voltage profile are considered as main objectives with constraints. The GOA is a metaheuristic swarm based optimization algorithm. It mimics the natural behaviour of grass hopper. The GOA is implemented on IEEE-30 bus system to solve OPF problem. Results show the ability of GOA to reduce the voltage deviation. It demonstrates that the GOA is capable to improve the voltage profile of system buses.

***Keywords*—** optimal power flow, grass hopper optimization algorithm, generator fuel cost and voltage profile, IEEE-30 bus system

I. Introduction

The requirement of the electricity is increasing exponentially in entire world. Most of the power stations are thermal power plants. Therefore, the requirement is to optimize the fuel cost of the power plants. The main objective of the power system is to give reliable power supply with economical operation and cost. Optimal power flow (OPF) is one of the tools for achieving this aim. It has been developed by Carpentier [1]. With the help of OPF the objective can be achieved with fulfilling the equality and inequality constraints. The objectives may be economical fuel cost of the power plant, voltage profile improvement, reactive power compensation, voltage stability and reduction in losses. From these objectives multi objective optimization problem has been formulated and solved with the help of different optimization algorithms [2]

Many researchers have been addressed the optimal fuel cost. Some researchers have been focused on the minimization of losses. OPF problem has been solved by nonlinear programming method in [3]. In this generation cost is optimized. Indirect approach has been implemented in [4]. It was based on Lagrange-khun-tucker method. It has been applied with different constraints like; voltage profile, loading of generators, limits of transformer taps, loading of transmission lines. In [5], the Newton method is applied to solve OPF problem. The Jacobean matrix has been used in [6] to grant optimal dispatch. Linear programming method has been developed in [7] to achieve optimal economical schedule. Linear programming based OPF has been formed in [8] for minimization of losses.OPF with FACTS has been proposed in [9]. In this, enhanced security constrained OPF with Han Powel algorithm is used. In [10-11], the OPF has been solved using interior point method

Different optimization algorithms have been used to solve the OPF problem. The Genetic Algorithm (GA) has been used in [12-14]. Particle Swarm Optimization (PSO) algorithm has been presented to solve OPF problem in [15-17]. The approached has been implemented for reactive power compensation and other objectives. The variants of PSO like multi objective PSO [18] in deregulated system, fuzzy PSO in [19] with increased search ability has been also presented. Artificial Bee Colony (ABC) has been used in [20-21] to solve OPF problem. Other optimization algorithms like moth flame (MFO) [22], harmony search (HS) algorithm [23] are also used for OPF problem.

No free lunch theorem (NFL) stated that the no optimization algorithms can solve all optimization problems. It motivates the researchers to solve the optimization problem with different optimization algorithms [24].

In this paper recently published grass hopper optimization algorithm (GOA) is used [25-26]. It is based on the natural behaviour of grass hopper swarm. This paper is comprising of four sections. Section I is introduction. Section II is GOA, section III deals with results and paper is concluded in section IV.

GOA:
GOA is an effective technique to solve optimization problem. It is based on the natural behaviour- movement and migration of grass hopper. In optimization technique- two phases are important- exploration phase and exploitation phase. In GOA the exploration phase is achieved by the adult insects of grass hopper travelling by forming swarm. The immature form of grasshopper has no wings. So it represents the exploitation phase of optimization by travelling in small area. The Fig.1 shows the image of grass hopper.

Fig. 1 Black and white image of real Grasshopper

The objective function is formed as given in [22].The bus voltage is one of the major criteria for reliable and efficient operation of power system. Here the main objective is to improve the voltage profile and reduce the fuel cost. The objective function (OF)is formulated as under:
OF= Fcost+ w* Fvoltage_deviation
where, Fcostis the fuel cost of generators,w is the weighting factor,Fvoltage_deviationis the voltage deviation at buses.

In this paper, the voltage at generator buses, real output power of the generator at generator buses, tapings of transformer and reactive power are considered as variables. The different constraints like- active and reactive power output of generator, shunt compensation, tapings of transformer and voltage are included.

II. RESULTS

The GOA is implemented on IEEE-30 bus system to improve the voltage profile and reduced the fuel cost of generator. It comprises of six generators as shown in Fig. 2 at buses 1, 2, 5, 8, 11 and 13. The bus 1 is considered as slack bus. The generation are denoted byPG1, PG2, PG5, PG8, PG11 and PG13and the voltages are denoted byVG1, VG2, VG5, VG8, VG11 and VG13.

The OPF is formulated here with GOA. The main objective here is to minimize the voltage deviation which results in improved voltage. The constraints are minimum and maximum values of generating costs, voltages, reactive power and transformer tap.

Table 1 and Table 2 shows the generation and voltages at considered buses with their minimum, maximum and optimized values. The GOA minimize the voltage deviation. As the iteration increases the voltage deviation starts decreases as shown in Fig. 3. The GOA minimized the voltage deviation through exploration phase in initial iterations and exploitation phase in later on. The voltage deviation is reduced to 0.1266 pu from initial high value (more than 0.6 pu).

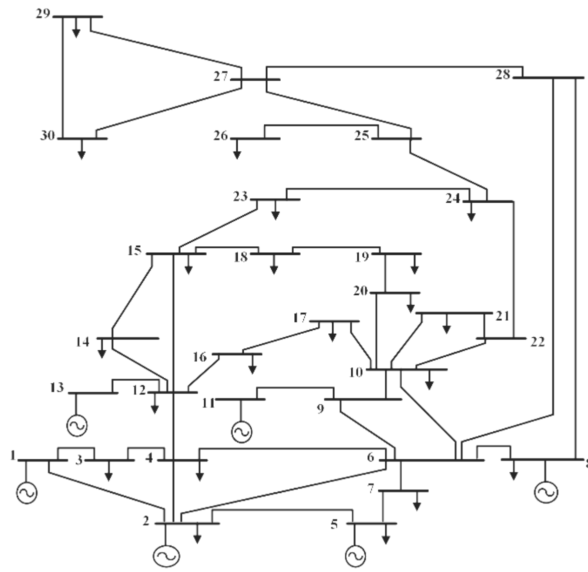

Fig. 2 IEEE 30 BUS SYSTEMS

Table 1
Optimal values of control variables- generating cost for voltage profile improvement with GOA

Control variables	P_{G1}	P_{G2}	P_{G5}	P_{G8}	P_{G11}	P_{G13}
Minimum	50	20	15	10	10	12
Maximum	200	80	50	35	30	40
GOA	174.91	49.09	21.47	21.55	13.03	13.12

Table 2
Optimal values of control variables- voltage for voltage profile improvement with GOA

Control variables	V_{G1}	V_{G2}	V_{G5}	V_{G8}	V_{G11}	V_{G13}
Minimum	0.95	0.95	0.95	0.95	0.95	0.95
Maximum	1.1	1.1	1.1	1.1	1.1	1.1
GOA	1.04	1.02	1.01	1.00	1.03	0.99

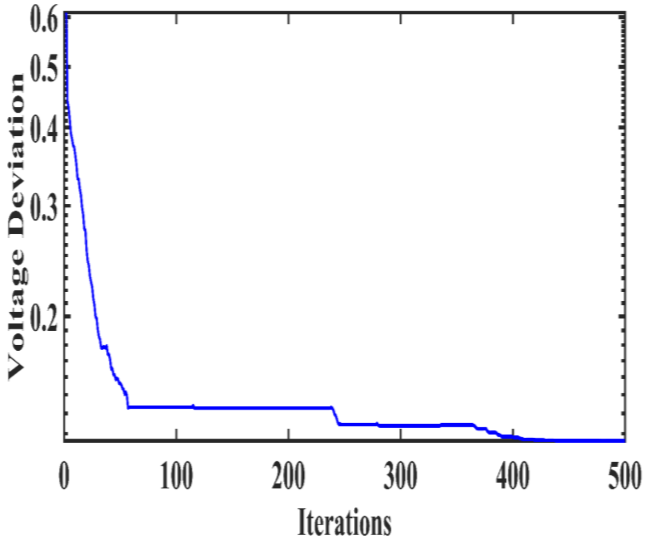

Fig. 3 Voltage deviation reduction

III. CONCLUSION

The GOA is applied to solve OPF problem with main objectives of fuel cost reduction and voltage profile improvement successfully. The voltage deviation value is formulated as an optimization problem considering required constraints. It is implemented on IEEE 30 bus test system. The GOA minimized the value of voltage deviation and improve the voltage profile. This is achieved with fulfilling the constraints.

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