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The New Planning of Voltage Stability in the Restructured Power System by using Teaching and Learning Algorithm

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Abstract - Because of the complexity of the restructured power system, voltage stability is very important in order to review and provide the appropriate solution to keep the system in a steady state after any disturbance and be able to suggest and run the best possible solution for each disturbance .in this case, The voltage profiles stay in the range of its own allowable variation. first of all, The methods of determining the voltage profile and conceptions of disturbance in the restructured power system is described. Then by learning how to get the optimal point and optimization algorithms conclude that If the voltage profile is calculated by using teaching and learning algorithms and load flow is computed by Newton Raphson, then we have gotten the optimal point. Hence, The independent operator of restructured power system can implement optimal points in the network by using the flexible transmission systems.

Keywords-voltage stability, restructuring, training and learning algorithm.

1. INTRODUCTION

In fact, determining the optimal point means to find the most suitable answer to a question with regard to certain conditions. With this description , a mathematical expression is optimized when the values of its variables is identified (it is dependent on the physical condition) in a way that the amount of which became maximum or minimum. Optimization can also be considered as a mathematical tool to find the best strategy to accomplish a certain task between several optimization methods which are used in all functional areas such as engineering or economics. Decisions problems means choosing between several different modes . Our goal is to obtain the best possible decisions. The Measure criterion of each of these selected modes is an objective function. Here, the objective function is the amount of voltage that by achieving the optimal point , we can help the network independent operator to ensure the stability of the restructuring power system. In optimization theory and its available methods try to obtain the best possible state among the series of conditions, just by the function of determined voltage [1]. Economic conditions in the world converted the power industry to a competitive market of energy which is remembered as restructured power industry. In the restructuring power industry, the independent system operator is obliged to provide system stability. in recent years ,Optimization field has been highly regarded by researchers. One reason is that, computer technology is advancing rapidly which resulting in the development of user-friendly software. On the other hand, The diversity and nominal dispersion and the performance of New optimization algorithms, has faced the users with problem of selection and proper understanding of their applications. Design, construction and maintenance of any engineering systems require a lot of technology and management decisions that are taken in several stages, The ultimate goal of such decisions is to maximize the desired profits or minimize the required effort. The necessary effort or desirable profit at any position can be expressed as a function of the decision variables. In examining the optimization algorithms , convergence and performance are considered as two important criteria.Some of these algorithms in spite of having good convergence, but may have a poor performance. This means that their optimizing process has not the necessary efficiency and speed . So far, many studies have been done in this field. Some of these studies by providing new approaches or applying evolutionary optimization algorithms to the problem, try to improve the answers[2]. Genetic algorithms and swarm algorithm of particle or birds are supposed as some of the studies which have been done in this field[3],[4]. In this paper, teaching and learning algorithms is used to improve voltage profiles in restructured power system. In order to obtain the correct voltage in the power system, first of all We should know by which method the load flow should be calculated in such a way that by correct selection of meta-heuristic algorithm for computing load flow,we can achieve to the optimal point[5]. In the past, to get the voltage in the power system, usually used of the conventional methods of load flow such as Gauss Seidel, Newton-Raphson, Decoupled, Fast Decoupled and DC load[6]. By studying and using various calculations of MATLAB and other applied algorithms in the power network ,we want to conclude that which method , among all existing methods of load flow, is more compatible with the best optimizing algorithm in power field. Therefore ,first of all by comparing the various methods of load flow,we can see which of them has the best speed and convergence, Then ,in continue, we determine which meta-heuristic Algorithm (used for calculation of load flow) can deliver us to the optimal point. algorithm of Particle swarm or bird's, learning algorithms and genetic algorithms are all suitable for load flow calculations. But after various calculations, we can conclude that by which of them ,we can obtain the optimal point. In The particle swarm algorithm or birds algorithm, all members are in relation to each other and by exchanging information , they can solve the problem. This algorithm is designed based on the group behavior of animals such as fish or birds. Teaching and learning algorithms is supposed as one of the newest evolutionary optimization algorithms that is based on teaching model of the teacher in a

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classroom. So far, genetic algorithm which is based on birth and selection of father, mother and children , is used in load flow field .but since the particle swarm algorithm and teaching and learning algorithm are newer, and they can lead us to better optimal points in power system. So ,in this paper after introducing them ,the mentioned algorithms are compared with each other in such a way to find how these algorithms can assist the Independent operator in calculations of restructured power system, easily[7]. First , we studied the load flow in the power system in order to determine the best solution by which we can best investigate the size of our network voltage in a restructured power system , using different algorithm. In the second part, particle swarm algorithm and how it applies in obtaining voltage is described , then , the third part represented the teaching and learning algorithm in determining the optimal point of voltage profile. finally In the fifth section, simulation results by the characteristic convergence curve and tables and the conclusions is presented.

2. LOAD FLOW STUDY

The flow of power from the producer to the consumer is defined as load flow . there is a difference in circuit computing in the power system Because in an electrical circuit by identifying the nodes and the entire flows ,the circuit can be understood and solved. But in the power system in order to calculate the voltage and Hershyn angle, active power and production and consumption reactive , various factors such as power coefficient, being producer and consumer should be considered and, all elements of the system should be identified. In Figure 1, P is the value of the productive power which flow from the generator toward the load, N shows the number of nodes, Bus is the number of shin and Load is concerned as the power system loads.

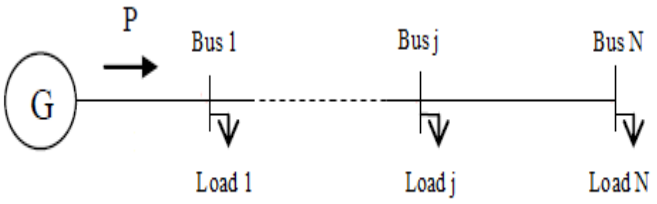

Fig. 1 Example power system to show power flow.

The first goal of load flow is to get the power flow in the power system and The second goal is to determine the load flow equations and the system inputs such as some laws like kvl, kcl that are not in circuit. In load flow equations ,The input are made by different materials, including active power (P) and reactive power (Q) and voltage (| V |) and voltage angle (δ). The output of the power system that has the same name as the input flow is calculated with load flow equations. Therefore ,The input and output in the load flow equations are completely different from orbital node equations. The introduction of load in the power system is different from the circuit one and is based on watts, kilowatts and ..... Power element can be checked on the basis of power which it will be determined according to the equipment unit, For example, transformer is calculated based on KVA and load is based on kilowatts or lamps is calculated by watt.

There are some Notes that should be considered in load flow study:

1. Acquire the power flow of plants in the power grid.
2. Input of grid equations are not the same.

In a power system ,we always expect that the grid behavior is DC. because in this condition, its casualties(losses) reaches to a minimum point and besides the voltage is always a Per-unit and resistance of power system is zero. In fact, the future development of the power grid due to the load growth , the need of adding generators, transformers and new lines in the system is not possible without the study of load flow. The study of load flow can also play a critical role in the investigation of current status of a system and making decision about its best operating condition. In general, we can say that calculating the load flow means solving a power system in its steady and symmetrical state[8].

Restructured power system is large and independent network operators should always find the optimal locations in the moment. But we do not use the usual mathematical methods for computing elements of power system. Because not only, it takes a long time ,but also user errors can also occur. So in this case ,it is better to use of numerical methods. By getting a set of answers, the error will be much less than pervious state, so that each of them is calculated mathematically. Two numerical methods such as Gauss - Seidel and Newton - Raphson in restructured power system have a practical application .they can be used to optimize the voltage profile .it means that by using one of the above methods ,we have to calculate the load flow elements .then by linking it to the selected meta-heuristic algorithm , the optimal point is determined. By comparing the numerical method Gauss - Seidel and Newton - Raphson realize that we can reach to convergence more quickly just by using Newton - Raphson. On the other hand, its writing is more easier and also, it is more suitable for large scale of power system. In this paper, we use of IEEE 30 bus power system to be able to keep voltage changes always up to five volts. As it can be seen in Figure 2 , according to the number of generators and consumer Shane, reactive power is always controlled in such a way that The voltage profile stays within the scope of its changes and the system will not collapse. If the consumption of active and reactive power become more than production of active and reactive one, then the system will collapse surely .in this condition, by providing constant load and controlling the amount of voltage by using equipment ,the network can be kept stable.

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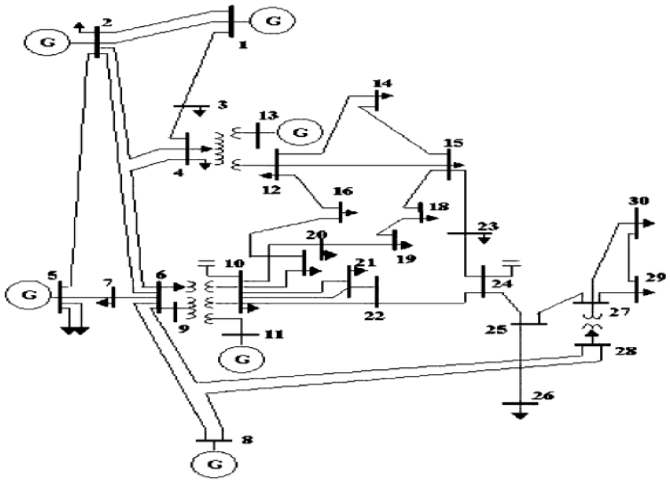

Fig. 2.30- bus IEEE sample system.

3. PARTICLE SWARM ALGORITHM

This algorithm was introduced with the idea of a swarm of birds or fish by James Kennedy and Russell C.Eberhart in 1995. Problems existing in the restructured power systems are non-linear and cannot be solved by mathematical methods. Particle swarm algorithm actually made of particles that move in the search space. And every bit try to maintain its own personal experience, including the position vector and velocity vector . On the other hand , all cumulative particle swarm, in turn, build and maintain the best experience. pbest is supposed as the best personal experience and gbest is considered as the best overall experience or the leader of the group. In the migration of birds or fish , the leader of the group tries to regulate the speed and position of the group. And any bird or fish should adjust its speed and position and match itself with other members of the group. In fact, this algorithm consists of three steps including the operating speed, the best personal experience and the group experience that has been updated gradually and it determines the next speed. Updating speed and position of each particle can be calculated by using of equations (1) and (2):

$$v_i^{k+1} = \omega\, v_i^k + c_1\, r_1 \left(pbest_i^k - x_i^k\right) + c_2\, r_2 \left(gbest^k - x_i^k\right) \quad (1)$$

$$x_i^{k+1} = x_i^k + v_i^{k+1}\Delta t \quad (2)$$

In the above equation, r1 and r 2 are supposed as the random number between zero and one, w is the coefficient of inertia, c_1 ,c_2 are learning coefficients that their sum should always be less than or equal to 4. The meaning of the index k + 1 in speed and position equations is the new speed .k is defined as previous position or speed. equation (2) represents the new location which is given by the position vector. So in this algorithm, each particle (bird or fish) with shifting (x) and changing the speed (V) can make a new experience that led to the overall experience. By using this algorithm, Voltage profile in the restructured power system can reach to the optimal point. However, particle swarm algorithm can stay in the local extreme points and not leave .here it should be reminded that because of the variables w,c1 ,c2 ,their speed is very slow. Optimization algorithm generally can be coded MATLAB programs . In single-minded problems like voltage profiles ,we have characteristic curve and optimal point that are reach to an optimal level after several iterations[9]. Here ,we want to solve the load flow problem for system listed 30 bus by using the particle swarm algorithm in order to reach to the optimal voltage, First, we define the variables that contains the maximum and minimum amounts of Shane (s), number (x-max & x-min) , learning coefficients and the coefficient of inertia .then we form the initial population (Ipop):

$$Ipop = round\left(rand\,(1, NN1) * (x\_max - x\_min) + x\_min\right) \quad (3)$$

In load flow program , the amount of voltage can be written by the equation (4),. Then, after the definition of population ,we can use of the voltage program of load flow which include calculation of voltage and other elements of the grid, then at the end of chain ,the objective function and speed are calculated accordance with equations (4) and (5) to determine the best answer.

$$voltagediviation = sum\left(abs\,(v-1)\right)/nbus \quad (4)$$

$$vel = rand \times (v_{min} + v_{\max}) + v_{min} \quad (5)$$

In the above equations, v is the value of bus voltage, nbus shows the number of buses, v_max, v_min presented the minimum and maximum speed changes according to the changes of position vector. Again, the speed is calculated by equation (1) and after the updating, the best overall answer is obtained. Since the power system is large and because of many variables pso, this algorithm has little convergence rate and in different iterations ,the answers are not so close to each other so they are not resistant. To solve the problem of Pso, genetic algorithms conduct us to a better points but compared to learning and teaching algorithms ,it is slow and contains errors.

4. TEACHING AND LEARNING ALGORITHM

TLBO is formed based on the teaching and learning process in a class. The algorithm first introduced by Rao and colleagues in 2011. This algorithm benefit from the learning ability of students in the classroom and the training process of the teacher to students, in order to improve academic level of the class. The teacher and students are two main elements in TLBO[10]. Accordingly, teacher's phase and student Phase are supposed as two important principles of this algorithm. The output of the algorithm is the scores of students and the level of their knowledge , hence quality and ability of teachers in this field is very rewarding. Thus, in each class, the teacher choose the best student in order to be able to help other students improve their grades . This process should be followed in teacher Phase. The students by learning from each other , try to improve their scores. So ,this process is followed in the student's phase.

TLBO algorithm is a modern Meta-heuristic algorithm which is based on population .and this population are members of the class. The fitness functions of each student is considered as a score for the students. The objective function in the optimization process should be minimized in a restructured power system. The Optimization process that was performed on class population, can be divided into two phases, teacher and student

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phases. In the teacher Phase, the teacher always tries to close the level of the knowledge of the students to his own level .but in reality, the level of students never reach to the level of the teachers .and it just only close to it .then it should be mentioned that the amount of being close to the surface of the teacher only depends on the ability of the classroom which is introduced in (7) deltax_ta equation. In student Phase, students increase their knowledge in two ways. One through the presence in the class and use of the knowledge of the teacher and the second way is happen by reviewing the course between themselves and other students. For this reason, in student phase ,there are two deltax_s. Now, we want to implement The teaching and learning algorithm in the load flow power system 30 bus according to Figure 2. Initially , we define variables which include the amounts and number of maximum and minimum Shane (x_max & x_min), number of population (NN1) and then we form the initial population (Ipop):
Generators variables, number of population, number of repetitions, the amount of load and the initial population function are defined as pso algorithm. Then ,The average value of the initial population is calculated on the basis of which we can define teacher phase by equation(relation) (6) and (7).

$$deltaX\_Ta^i = rand(\,) \times (Ta^i - F \times M^i\,) \quad (6)$$

$$F = round\,(1 + rand\,(1,1)) \quad (7)$$

In the above equation, x_ta represents the teacher phase, ma shows the average number of population according to the objective function and here, the objective function is the voltage profile which is updated by equation (8). Equation (8) is defined in the Newton – Raphson load flow program. After we determine the population , we use the program, variable of student is defined just as the same as variable of teacher. By considering this difference that student variable ,as we mentioned before, happen in two step and x-j shows that each student randomly exchanging views with other ones. By observing the characteristic curve in Figure (4) finds that the objective function is resistant and by little changes in each iteration, we can get the optimal solution more quickly than pso algorithm.

$$voltagediviation = sum(abs\,(v - 1))/nbus \quad (8)$$

5. SIMULATION

The characteristic curve after 100 repetitions is shown in Figure 4 .as you can see after the number of iterations ,we can reach to the optimal point . so, the curve is robust (resistant). This means that the amount of changes in the objective function in each repetition is very low and by consistency ,we can achieve the optimal point. Since ,in each implementation of algorithm in the problems of restructured power system have a new answer due to random variables ,so these answers should not have a lot of differences with each other and surely, they are close together. The criterion of comparison of algorithms in restructured power system is characteristic curve. the independent network operator can always find the optimal point with the correct selection of algorithms and ensure system stability. By observing the convergence characteristic curve in Figure 4, we learn that teaching and learning algorithm is resistant. And with little change in each iteration can achieve the optimal point more quickly than pso algorithm. Figure 3 represents the implementation of meta-heuristic algorithm pso in load flow of power system 30 bus by optimizing voltage profile .figure 4 represents the result of using TLBO algorithm in the load flow of 30-bus power system by optimizing the voltage profile. In chart 1 ,there is a comparison between the implementation of both algorithms in the restructured power system. As you can see that ,TLBO algorithm has higher speed and thus the more computational aspects of the power system can take into account.

The simulation results of elected meta heuristic restructured power system are used numerically to determine the optimal point of voltage which can be seen in Tables 1,2. table 1 represents the optimal points of voltage by pso algorithm and in table 2 the optimal points of voltage by TLBO algorithm is shown.

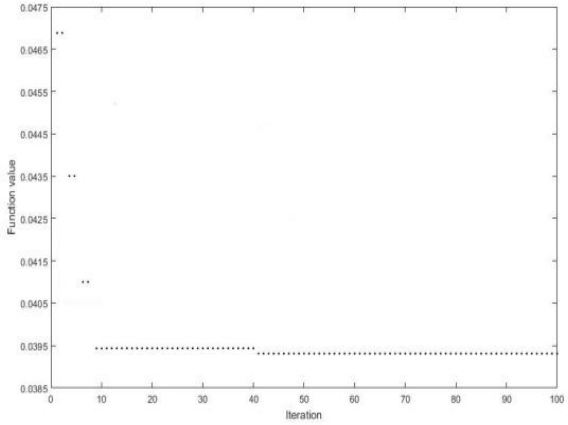

Fig. 3. Convergence graph of voltage diviation function by the use of PSO.

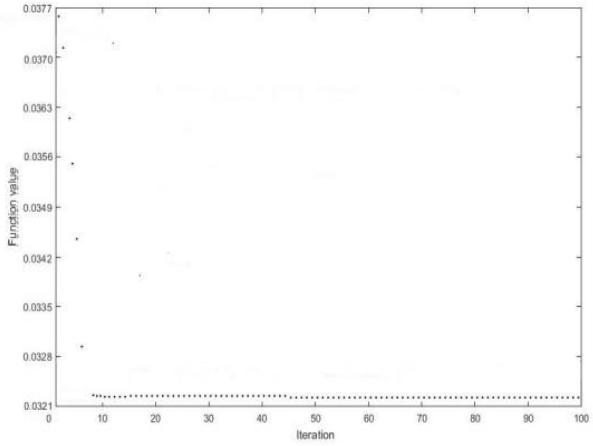

Fig. 4. Convergence graph of voltage diviation function by the use of TLBO

Table. 2 the optimal solutions which are found by PSO.

repetition	Controlling shane			The value of reactive			Total answer
1	27	11	8	11	31	23	0.0470
2	27	11	8	11	31	23	0.0470
3	28	2	10	10	99	12	0.0435
4	11	28	2	70	6	14	0.0409
5	11	28	2	70	6	14	0.0409
6	28	2	20	0	23	12	0.0395
7	7	1	15	15	11	20	0.0381

Table. 3 the optimal solutions which are found by TLBO.

repetition	Controlling shane			The value of reactive			Total answer
1	8	11	27	23	31	11	0.0371
2	7	11	28	25	75	48	0.0365
3	6	10	28	99	12	10	0.0361
4	6	11	28	6	70	6	0.0355
5	8	12	26	11	2	14	0.0345
6	6	11	28	23	12	0	0.0329
7	7	10	27	11	15	20	0.0321

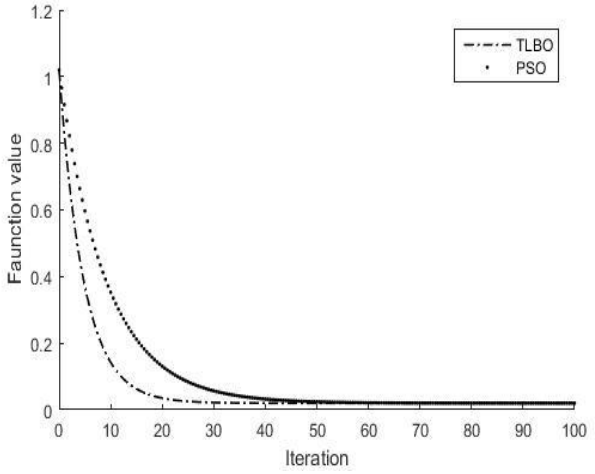

Chart.1. comparison between characteristics of PSO and TLBO.

6. CONCLUSION

In this paper, by using the load flow method of Newton-Raphson, we have increased the convergence rate in the restructured the power system with more high-sheen dimensions then we have calculated the elements of grid IEEE-bus. But for the stability of the restructured power system ,we will help a network independent operator to optimize the result of load flow for voltage by using of TLBO meta-heuristic algorithm. This mentioned algorithm in comparison with other meta-heuristic algorithms has higher speeds and fewer errors in the calculations of the load flow of power system.

In this case, the network independent operator by voltage stability not only can increase the technical quality of power system ,but also can decrease the existing costs by selecting an appropriate purchase of power plant. If the operator cannot guarantee network stability with proper planning, then it is persuaded to maintain the stability of the system just by paying more purchase cost of power plants. Therefore, it is suggested that independent operators of restructured power system by using TLBO meta-heuristic algorithm and the Newton-Raphson method try to have a proper planning to be able to handle the Shane of restructured power system in order to maintain voltage stability.

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