Teaching Learning Best Optimization Technique for Optimal Positioning of FACTS Devices in Power System

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Abstract— This paper presents the Teaching Learning Best Optimization. We are used with the optimal power flow (OPF), by adding Flexible Alternating Current Transmission System (FACTS) equipment with the power system, for decreasing losses, keeping the voltage level of the system within the desired level. The simulations are executed to get the best parameters of two FACTS devices namely, Static Var Compensator (SVC) and Static synchronous compensator (STATCOM). The execution is carried out considering IEEE 14 and 57 buses as the test system. The results obtained and comparison with other technologies show that the optimization technology based on teaching and learning provides an effective and powerful high-quality solution when solving the optimal power flow problem with different complexity.

Index Terms—Optimal location, FACTS devices, SVC, STATCOM

I INTRODUCTION

The main aim of the power system is to supply the demand power to the consumer and to reduce the transmission loss, voltage and frequency. If the energy demand increases it leads higher requirement from the power system. Due to numerous reasons the transmission zone has facing high transformation. The primary reasons are, change in regulations, essential to fulfill power order by different load, which leads to overloaded power system. Unimpeded flow of power, unpleasant voltage profile and overhead losses of power during transmission, these are the some characteristics of such systems. The issue of excess power system is further increases because of retard in placing new transmission lines. Under such constraints, it is difficult to fulfill best functioning of transmission lines load demands, forcing electrical utility industries to overcome all these problems with alternative solutions.

An electrical power transmission network contains mainly 3-phase alternating-current (ac) transmission lines operating at individual transmission voltages With high necessity of power transmission capacity and overlong transmission distances the transmission voltages continue to rise; in fact, increases in transmission voltages are connected closely to decreasing transmission losses.

The FACTS are the power electronic devices, they are installed to make the system electronically controllable at the high voltage side. These controllers increase the secure working limits of a transmission structure without affecting solidity, these controllers operates very fast. The main aim of the FACTS is the evolution of latest solid state electrical switching devices. With the utilize of FACTS devices inside the working limitation of current transfer thermal limits of conductors, voltage limits of insulating equipment, and systemic limits, an operative must be skilled to manage flow of power on lines to firm the defense side, and also broadcast electrical power at a minimal of set off budget. The concept of the FACTS device was proposed by Hingorani in 1988. Power transmission across the transmission line is based on the voltage amplitude and phase angle difference across them and the reactance of the transmission line. There are different types of FACTS devices, in this paper we are using the most essential FACTS devices Static var compensator (SVC) and Static Synchronous compensator (STATCOM).

II TEACHING LEARNING BEST OPTIMIZATION ALGORITHM

The Teaching Learning Best Optimization (TLBO) algorithm is a new population-based algorithm invented by Rao et al. The algorithm illustrates the teaching abilities of teachers and learners in the classroom. In this method population is a number of students (learners) in a classroom and design variables are the topics present to the students (learners). The results of students (learners) can be compared with fitness values, and the rate of the objective function constitute the knowledge of a specific student. Teacher is observed as highly learned person, so the best solution is parallel to teacher in the TLBO. There are 2 parts of process for TLBO, 1st part consist of 'Teacher phase' and the second part consist of the 'Learner phase' means learning through the interaction between learners.

III METHODOLOGY

We are used MATLAB for simulation and analyzed the result using TLBO algorithm. The TLBO algorithm explained here is shown in the flow chart of figure 1

Step 1 : Number of students in the initial class (N), number of generations (G), number of topics provided, the number and the number of units placed in the distribution system (D) and the limits of design variables

The optimization complication is defined as: Minimize (x) , $f(x)$ is a function of objective, X design variable.

Step 2 : create a random population accordant to the number of students in the class (N) and number of subjects provided (D). the mathematical expression for this population is

$$V = \begin{bmatrix} X_{1,1} & X_{1,2} & . & . & X_{1,D} \\ X_{2,1} & X_{2,2} & . & . & X_{2,D} \\ . & . & . & . & . \\ . & . & . & . & . \\ X_{N,1} & X_{N,2} & . & . & X_{N,D} \end{bmatrix} \quad (1)$$

Where $X_{i,j}$ is the initial grade of the j^{th} subject of the i^{th} student.

Step 3: Assess the mean grade of each course given in the class. the average grade of the j^{th} subject at generation g is explained as

$$M_g = \text{mean}\,(X_{1,j}, X_{2,j}, \ldots\ldots, X_{i,j}) \quad (2)$$

Step 4 : From the grade value generated classify the students from finest to worst. The best answer is observed as teacher and it is given as :

$$X_{teacher} = X|_{f(X)=min} \quad (3)$$

Step 5 : Alter the grade point of each course of each student. Altered grade point of the j^{th} course of the i^{th} student is given as :

$$X_{new^g(i)} = X_i^g + rand \times (X^g_{Teacher} - T_F\, M^g) \quad (4)$$

$$X_{new^g(i)} = X_i^g + r1 \times [X^g_{Teacher} - (round\,(1 + r_2) \times M^g)] \quad (5)$$

Where r_1 , r_2 are random numbers between [0, 1].

Step 6 : Each learner enhance grade point of every topic by the mutual interaction beside the other learners. For a given learner, The grade point of the j^{th} learner is changed by

$$X_{new^g(i)} = \begin{cases} X_i^g + rand \times (X_i^g - X_r^g) \; if \; (X_i^g < X_r^g) \\ X_i^g + rand \times (X_r^g - X_i^g) \quad otherwise \end{cases} \quad (6)$$

FACTS equipment are power electronic based devices and these devices is installed in the AC transmission line. The important features of these devices are they provide increase in power transfer capability, stability terminated series or shunt compensation. Here we are using SVC and STATCOM. The main intension of using SVC is to manage the voltage level at a particular bus. Same as another device STATCOM is used During fault condition STATCOM own the capability to supply high capacitive reactive power.

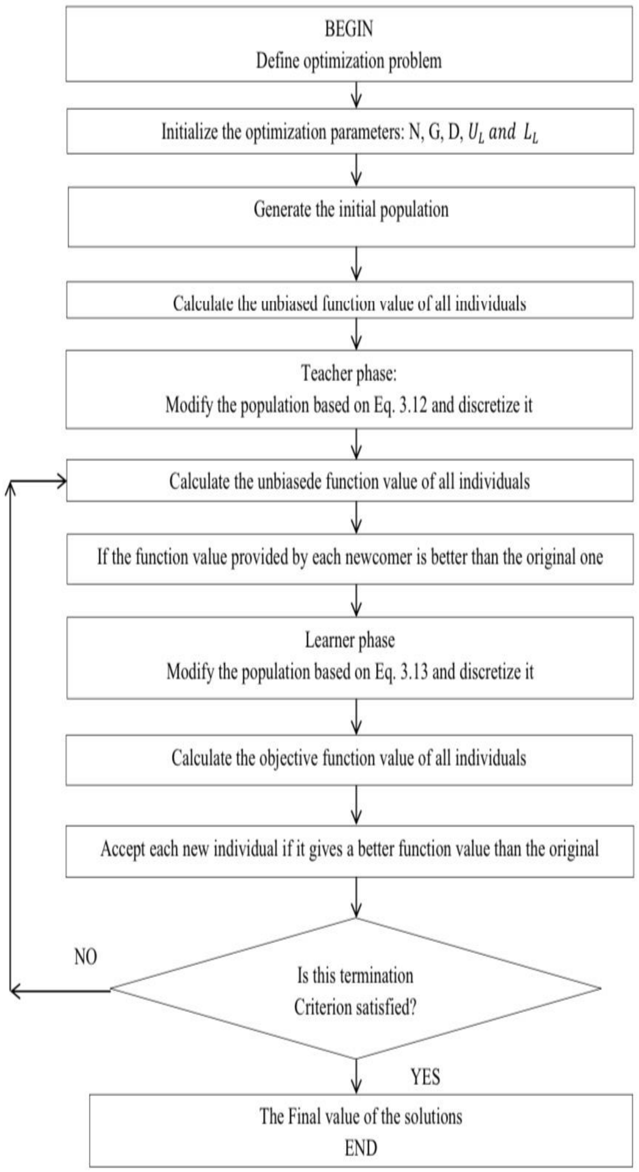

FIGURE. 1 **:** Flowchart diagram of TLBO algorithm

IV SIMULATION RESULTS AND DISCUSSION

The function and simulation were carried out using MATLAB, math works creation. The simulation results are as fallows,

Fig 2 shows the voltage variation of IEEE 14 bus system without FACTS devices. voltage level is very low, So voltage range is almost in same level as we can see in the below figure

FIGURE 2 : Voltage variation of IEEE 14 bus system without FACTS devices

For IEEE-14 bus system the FACTS equipment of STATCOM and SVC are connected and after performing simulation the power flow solution results are shown below. Here we can get the final solution value, after comparing with previous value. So that leads to the best place to insert the FACTS devices..

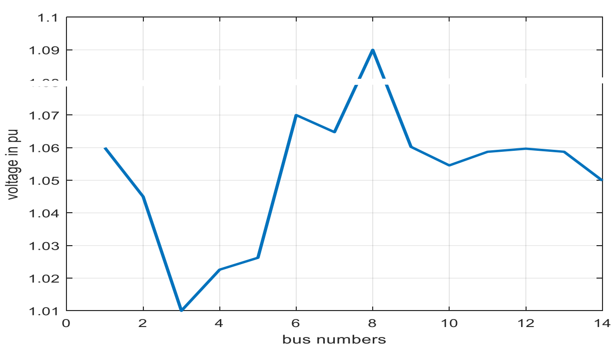

FIGURE 3 : Voltage variation of IEEE-14 bus system with FACTS devices

The results are taken from the simulation of 3 iterations for each bus and the best position for FACTS device is identified. The results of voltage profile and best location for FACTS equipment in IEEE 57 bus system graph is represented below. From the graph we can see the difference between both conditions of FACTS equipment.

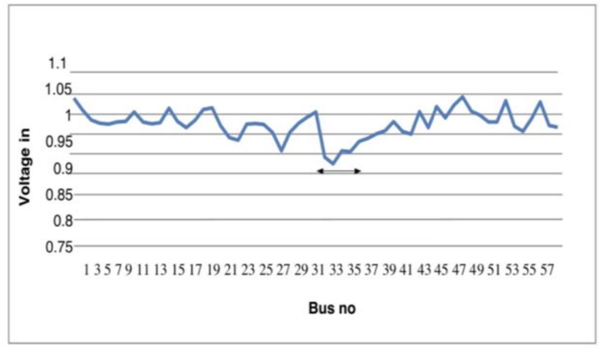

FIGURE 4 : Voltage variation for IEEE-57 bus system without FACTS

From the graph we can see the difference between both conditions of FACTS equipment. Fig 5 shows variation of voltage for IEEE 57 bus system adding FACTS devices.

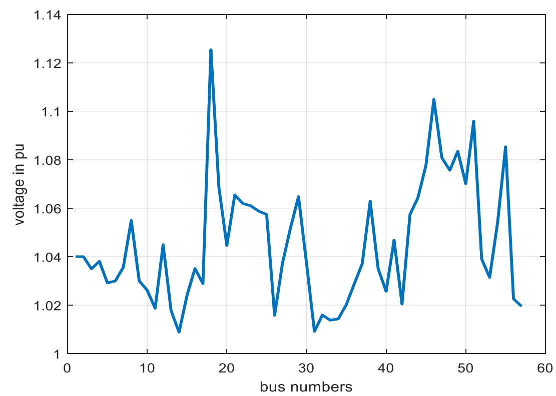

FIGURE 5 : Voltage variation for IEEE-57 bus system with FACTS

V CONCLUSION AND FUTURE SCOPE

From the simulation results obtained using TLBO we can conclude that with and without FACTS devices we can see the difference between the losses and voltage variations. From the result, once we identify exactly where that FACTS device has to be connected in power system, the difference we can see and it is possible when the TLBO algorithm is applied for the simulation. The results shows that, when calculating the optimal power flow problem with different complexity, the optimization technology built on teaching and learning provides an effective and powerful high-standard solution.

The optimal positioning and sizing of problems in distributed system generation units particularly in various systems can be computed by the simulation of Teaching Learning Best Optimization algorithm. For radial distribution system this method is very effective. This method is even has the capacity of addressing the modeling challenges have a need of the radial distribution system.

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