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Power Loss Minimization in Transmission System using Particle Swarm Optimization and Salp Swarm Algorithm

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Abstract –When electrical energy is transmitted from generation plants to users through transmission and distribution networks, energy and power losses occur, due to the physical characteristics of the network components. These losses are inherent in the conduction of electrical energy through physical means and cannot be completely avoided. There are significant opportunities to improve the energy efficiency of existing networks and future extensions. Improving efficiency means implementing measures that take levels of effectiveness beyond accepted practices for the activity. There are a number of practical measures and technologies that can be implemented to reduce network losses. This paper presents a power loss minimization framework for TCSC (Thyristor Controlled Series Compensator) with the use of metaheuristic methods used to minimize the power loss. Particle Swarm Optimization (PSO) and Salp Swarm Algorithm (SSA) are used to find the optimal location of TCSC for IEEE-14, IEEE-33, and IEEE-57 bus test systems. Performance analysis is done on the basis of active and reactive power losses.

Keywords – Active Power, FATCS, PSO, Reactive Power SSA, TCSC.

1. INTRODUCTION

The FACTS by means of the acronym "Flexible Alternating Current Transmission System" are devices that by means of the activation of semiconductor elements of power, allow to improve the capacity of power transfer between a point of consumption and one of generation, for this purpose, the variables of the system influenced by the flexible compensators are, the voltages of the nodes, the series impedances of the lines or the phase angles. In any case it is translated. In a control of active and reactive power flows, although the one of more interest usually is the decrease of the reactive one.

Characteristically the FACTS present advantages over traditional methods of control reagents in power systems, by the ability to intermittent in short and repetitive time periods that are mainly dependent on the variability of the system demand [1].

When the network is disturbed (Short circuit, loss of a load or a group, opening of a line, etc.), the difference between the mechanical and electrical powers leads to an acceleration or deceleration which may lead to the loss of synchronism of one or more generation groups. The rotor angles oscillate until the adjustment systems protection in order to restore the march in synchronism and lead the network to a state of stable operation.

However, the demand for electricity varies constantly over the course of a schedules, weather conditions, other criteria are also taken into account such as holiday periods, holidays, weekends, holidays and events that (strikes, sporting events, etc.). For this purpose, the design of the electrical system has been made in such a way that an entire inseparable chain is integrated beginning with: production, transport and distribution to consumers. One cannot store large quantities of energy in electrical form, it is the problem is forced to produce the same quantity of electricity that must be consumed; we also know that the production groups have certain technical limitations which must not be exceeded which leads us to another problem too complicated one can translate it mathematically a non-linear problem [2].

Therefore, the economic distribution of electric power produced by power stations at particular marginal cost; has become the object of research and studies over the years. This process has been under study since 1928 due to its great importance in electric power; the numerous publications on this subject are clear proof. Several methods and algorithms have been applied to solve this problem achieving better results. Early research has neglected losses in lines subsequently several improvements of the original proposal have been developed by introducing the losses as well as the operating limits of the production groups. Arriving at their final shapes; algorithms based on marginal costs take into account:

- Fuel costs and their efficiencies.
- Operating and maintenance costs.
- Operating limits and operating areas prohibited.
- Unit response gradients.
- Transmission losses (penalty factors).
- Reserve constraints.

These algorithms prove their efficiencies and provide better results, but another result is the time factor. Thanks to the development of "smart grids", a transition has been made towards a market more dynamic, fast and efficient. Recently, the techniques of neural networks are beginning to be used in different fields of study of electrical networks, including forecasts of consumption, load distribution and Economic Dispatch. The use of the method of neural networks makes it possible to avoid the disadvantages encountered by classical methods and more precisely lost time; as well as this method is convenient to take into account the various non-linear and random factors.

2. CONTROL OF TRANSITS

In a mesh interconnection network, the distribution of energy transits depends essentially:

- Location of loads.
- The location of production groups in operation.
- Cross-border trade.
- Location of reactive energy compensation means.
- Impedances of the transport structures.

These transits of energy constitute a flow from the stations where customers are connected; it borrows the lines and the transport cables in distributing in proportion to the inverse of their impedance. What is, in a way, a preference marked for the "shortest path". This flow of energy is materialized by the current crosses the structures. The higher the energy flow, the more current currents will be strong. These intensities may increase, particularly when a structure is triggered by a defect. Indeed, the transit initially supported by this structure will be referred to the neighbour’s structures; it is the phenomenon of transfer of charge.

The regulation of transits is ensured by playing mainly on two parameters:

Topology of the Network: By adapting the operating diagrams, the dispatcher modifies the impedances of the different meshes of the network (creation of long queues to increase the impedance of the network or, on the contrary, works in order to reduce it) and plays on the distribution of production sources.

Production Programs: By adapting the production programs of the groups, the dispatcher plays on the distribution of sources of production versus loads. In the ultimate situation, the last resort is to act on the charges by shedding customers. For a given topology, it is possible to evaluate, using the driving and simulation tools, the transits in each of the works according to the adopted production plan and the location charges. In the same way, it is possible to calculate the impact of the triggering of a transport structure or production, on the value of transits in the remaining works [3] [4].

3. STATE OF THE ART

A very large part of power losses in electric networks is associated with distribution losses. Of all the power transmitted by dissemination organizations, power misfortunes are assessed at 14%. The degree of these misfortunes, coupled with the deregulation of the electricity market, prompted distribution companies to seriously consider the issue of misfortunes in circulation networks so as to expand power transmission before pondering putting resources into the development of new lines.

For this line setup and considering that the requirement for dynamic force is in compressible, the decrease of voltage drops and force misfortunes can be accomplished distinctly by diminishing the entry of solid receptive parts of the line current. For this purpose, reactive energy compensation is recommended and one of the most indicated means is the application of shunt capacitor batteries which is the subject of the present disclosure. However, it is not enough to place batteries of capacitors to say that the problem posed (circulation of strong reactive currents) is solved.

The optimization of the reactive energy compensation is to be understood as the choice of the powers of the capacitor banks, their locations and even the time during which they will remain in line if it is an adaptive compensation. Of course, these choices must be made so that there is the least power loss in line and an improvement in the voltage profile while having a positive economic return. The choices of the objective function are dictated by the concern to take into account both the electrical and economic aspects of the problem. The objective function, over which all authors involved in the issue of advancing responsive vitality remuneration, is the purported monetary bring capacity back (saving function). However, since the installation of capacitor banks reduces not only active losses, but also reactive power losses, unlike all the authors who dealt with a problem of concern, this article will introduce the objective function of reducing reactive power losses.

Therefore, the goal is to determine the battery capacities and their location in order to minimize power losses, improve the voltage profile and thereby increase the throughput of these lines.
Since the problem of optimizing the reactive energy compensation cannot be separated from the power flow then the solution of the latter will be studied.
A significant number of works have addressed the problem of optimizing the reactive energy compensation in distribution lines, i.e. determining capacitor bank sizes and their locations to reduce power losses in the line. Methods can be classified into four categories: analytics, numerical programming, heuristics, and intelligence and meta-heuristics.

In recent decades, a number of techniques have been developed to resolve the issue of power flow in distribution networks. Since it is not possible to give all the work carried out in this direction, it will be sufficient to describe some of them only. Among the authors who dealt with this problem is Mahmoudi et al. [5] in 2018 gave a solution of power flow in radial and weakly meshed distribution networks. When the network is meshed, the meshes are broken and fictitious nodes are created, these nodes whose number of loops and the power flowing there are negative. The model of load considered is the model with constant impedance. In [6] Bhullar et al. in 2017 proposed a method for solving recursive relations, a function of the tensions based on scanning up and down the line. Ghatak et al. [7] in 2017 also proposed an iterative method. It uses the fundamental principles of theory of equivalent circuits of Thevenin, to determine the factors of stability of the tension whose determination requires the knowledge of the tensions of the nodes therefore the solution of the flow of charge. Mary et al. [8] in 2017 proposed an iterative strategy that is utilized both in spiral organizations and in powerless work organizations. At that point he changes over the organization, in the event that it has a lattice, into an outspread organization, breaking the matrices, hence making invented hubs, the quantity of which is equivalent to the quantity of circles and where the powers that flow there are negative.

Then, it determines the tensions of the nodes and their phases at the origin by sweeping the line up and down. It initializes the tensions of all nodes to that of the source whose relative value is equal to one. Yang et al. [9] in 2018 presented a formulation and algorithm towards solve the problem of power flow, aimed at large three-phase lines. The solution technique is based on sweeping up and down the line. Pathak et al. [10] in 2018 which will give a method involving the evaluation of simple algebraic expression. The method that it proposes is iterative and or at the first iteration the tensions of the nodes are initialized to 1 in relative value. It then calculates the load currents and the branch currents as a result of which it determines the voltages of the nodes. Parihar et al. [11] in 2017 examined the effects of different load models the union of the force stream technique. The method on which it was created has been actualized and introduced as a product called "distriflow" fit for performing power motion investigation for a spiral conveyance organization of quite a few busbars. Babu et al. [12] in 2016 developed a technique for ascertaining power stream in dissemination organizations where multiple sources operate. The method of solution is identical to that given in reference [8]. It considers, for the solution, of problem, that the network is single source. The rest of the sources are simulated by an injection of power at the points of their connections (negative powers). Fazio et al. [13] in 2018 also proposed an iterative method in which the tensions of the nodes are assumed to be equal to that of the voltage source (1pu). They first gave the shape of the branch-to-node incidence matrix, then he calculated the branch currents and the node tensions. As a criterion of convergence, they proposed the difference between the tensions of two successive iterations.

5. PROPOSED METHODOLOGY

A. Thyristor Controlled Series Compensator (TCSC)

This device is widely used for the control of flow of power in the transmission lines through a series compensation. The function of a TCSC, is to modify the impedance of the line, inserting capacitors or inductances in series with the circuit to modify the power flow. The capacitive compensation is the most used, because it helps to verify the natural inductive effects of the transmission lines.

The advantage of the TCSC over conventional stabilizers is that these latter use devices with mechanical drives, which over time and use tend to wear out and suffer breakdowns, whereas the TCSC when using static drive devices based on Thyristors do not have this problem due to mechanical stress [14].

For the modeling of a TCSC in a transmission line, the simplified PI model is taken from the line and in series to the line impedance, a X_{TCSC} variable reactance is placed, representing the inductive or capacitive capacitance that the compensator has over the Line as shown in Figure 1.

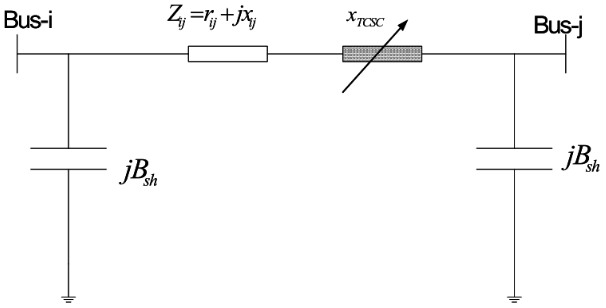

Figure 1: Diagram of a Transmission Line Compensated with a TCSC [15]

B. TCSC Modeling

The compensator will freely move among reactance principles and during stable state as per its power. Limits based on the equation (2) for reactance oscillation are suggested to prevent over-compensation of the line.

$$-0.8\,X_L \leq X_{TCSC} \leq 0.2\,X_L\,p.u. \qquad (2)$$

The suggested limit differs between various experiments, but an average of capacitive factor greater than 50% of line resistive and inductive factor less than 25% of line inductance are established.

In order to be used in a power flow, in order to achieve the scheme shown in fig.2, the device must be at a line impedance with the built-in transformer reactance. The reactance variations introduced by the compensator are represented in this figure via the equation of variation (2).

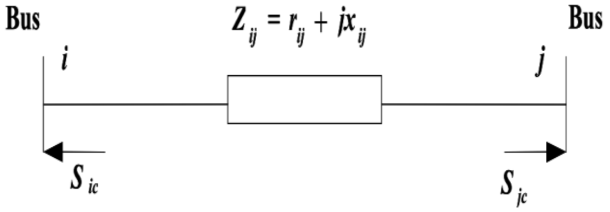

Figure 2: TCSC Power Injection Model [15]

$$\Delta y_{i,j} = y'_j - y_{i,j} = \left(G'_{i,j} + jB'_{i,j}\right) - \left(G_{i,j} + jB_{i,j}\right) \qquad (3)$$

Where

$$G_{i,j} + jB_{i,j} = \frac{1}{z_{i,j}} \qquad (4)$$

$$G_{i,j} = \frac{r_{i,j}}{r_{i,j}^2 + x_{i,j}^2}, G_{i,j} = \frac{-x_{i,j}}{r_{i,j}^2 + x_{i,j}^2} \qquad (5)$$

$$G'_{i,j} = \frac{r_{i,j}}{r_{i,j}^2 + \left(x_{i,j} + x_{TCSC}\right)^2}, G'_{i,j} = \frac{-\left(x_{i,j} + x_{TCSC}\right)}{r_{i,j}^2 + \left(x_{i,j} + x_{TCSC}\right)^2} \qquad (6)$$

In function (3) it is stated that in fact there is a variation of admittances by the presence of the compensator, so that the admittances matrix will also be affected in the mean indicating (7).

$$Y'_{BUS} = Y_{BUS} + \left[\begin{array}{ccccccc} 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & \Delta y_{i,j} & 0 & \cdots & 0 & -\Delta y_{i,j} & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ 0 & -\Delta y_{i,j} & 0 & \cdots & 0 & \Delta y_{i,j} & 0 \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ & Col-i & & \ldots & Col-j & & \end{array}\right] \begin{array}{l} \\ \\ \\ Row-i \\ Row-j \\ \\ \\ \\ \end{array} \qquad (7)$$

In terms of power flows between bars, the equations denoting power with the addition of the compensator can be written for active and reactive power flow, applying the admittance variation produced by the compensator series so that they are obtained [16, 17]:

$$P_{ijrCSC} = V_i^2 G'_{i,j} - V_i V_j [G'_{i,j} Cos(\delta_{ij}) - B'_{i,j} Sin(\delta_{ij}\,)] \qquad (8)$$

$$Q_{ijrCSC} = -V_i^2 \left(B'_{ij} + B_{sh}\right) + V_i V_j [G'_{ij} Sin(\delta_{ij}) - B'_{ij} Cos(\delta_{ij})] \qquad (9)$$

C. Algorithm for TCSC

For the case of the compensator algorithms, two considerations are necessary for its modelling and simulation, the modelling translates into defining the variations that introduce the compensators and for the simulation to be considered, if this value will be subject to changes according to the method of Solution of power flows, as the iterative method evolves.

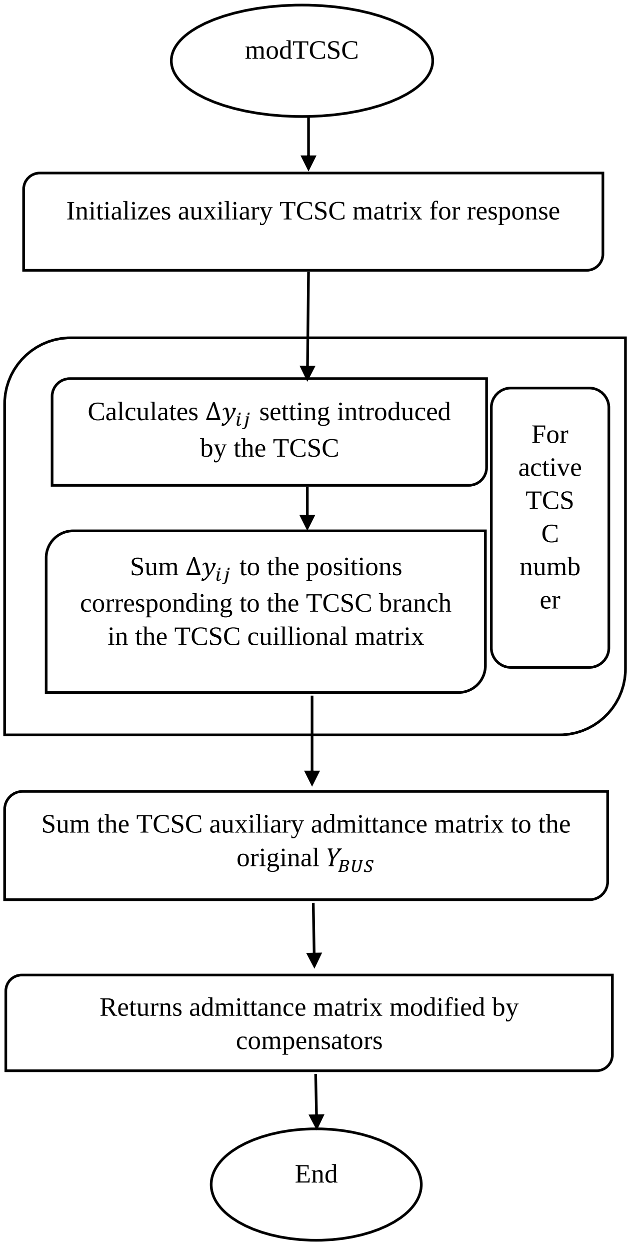

Figure 3: Algorithm for TCSC

The "modTCSC" function adjusts the admittance matrix as presented in the upper section, in a magnitude as a function of the same serial admittance of the branch, and may have an inductive or capacitive behaviour.

The algorithm of modifications introduced by TCSC receives, an information matrix of TCSC, the system admittance matrix without TCSC, a TCSC location vector, and the dimensions of the admittance matrix.

The second condition mentioned above is related to the place that will be given to the compensator in the program to calculate power flow, this place should be in accordance with the variables that modify the compensator.

In this case, the TCSC changes the serial admittance of a branch of the system, so its location must go after the admittance matrix is computed without compensators and it does not depend of any parameter that changes during the iterations as the voltage, it is not necessary to place it within the loop of the iterative method.

In order to avoid that the "modTCSC" function is called without active TCSC, a conditional is placed that allows to start the function only on the test of active compensators, this conditional is used for the three types of compensators treated in this document and use a column to State of operation in each compensator that marks with one the operation and with zero the non-operation of a compensator in an extension or bar.

D. Problem Formulation

Losses of control , low voltage level & voltage profile degradation have paid great attention to the distribution networks and the strong currents circulating there in order to limit their intensities and thus improve the quality of energy supplied to consumers. The limitation cannot be done, if the network is not reconfigured, by acting on the reactive components of the branch currents then, the most indicated means is the installation of batteries of shunts capacitors. The installation of capacitor banks must be done rationally, i.e. in such a way that the quality of the energy is improved without, however, making major investments which would increase the energy consumption.

Therefore, the problem is deciding the quantity of batteries, their forces, and their areas, which would make a target work greatest "F". Accordingly, this target transforms the issue of receptive vitality pay into an improvement issue. Be that as it may, because of the discrete idea of the battery sizes and their area, this issue isn't straight and has limitations. It is commonly displayed as follows:

$$\begin{cases} \max f(x,u) \ \ subject\ to: \\ \quad x_{min} \leq x \leq x_{max} \\ \quad u_{min} \leq u \leq u_{max} \\ \qquad g(x) \geq 0 \end{cases} \tag{10}$$

Where, f: is the target function is to increase.

g: is the restriction on equality is. The collection of wave equation is the series of$x$: is the control variable vector

u: is the state variable vector.

4.1 Reduction of Active Power Losses

The decrease in power losses attributable to the 'k' battery is proportional to the gap in the network's active power losses during the capacitor bank is mounted. It is depicted as:

$$\Delta P_k = P_{av_k} - P_{ap_k} \tag{11}$$

Where,

P_{av_k} represents the active power losses before compensation.

P_{ap_k} represents the active power losses after compensation.

4.2 Reduction of Reactive Power Losses

The disparity between the losses before and after the installation of the batteries in the capacitors is determined by the reduction in reactive power losses due to a battery mounted at node 'k' of the distribution system. It is depicted as:

$$\Delta Q_k = Q_{av_k} - Q_{ap_k} \tag{12}$$

Where,

Q_{av_k} represents the reactive power losses before compensation.

Q_{ap_k} represents the reactive power losses after compensation.

4.3 Reactive Power Losses

The voltage regulation losses in a delivery network line consisting of n branches are suggested by the following formula:

$$Q_{av_k} = \sum_{i=1}^{n} x_i I_i^2 \qquad (13)$$

Where,

x is the reactance of branch i

I_i is the line current of the i^{th} branch?

The active and reactive components of the branch current thus cause the losses of reactive power to be written as follows, as with active power losses:

$$Q_{av_k} = \sum_{i=1}^{n} x_i I_{ai}^2 + \sum_{i=1}^{n} x_i I_{ri}^2 \qquad (14)$$

The power system losses when a capacitor bank is mounted on a k-node is calculated by:

$$Q_{ap_k} = \sum_{i=1}^{n} x_i I_{ai}^2 + \sum_{i=1}^{k} x_i (I_{ri} - I_{crk})^2 + \sum_{i=k+1}^{n} x_i I_{ri}^2 \qquad (15)$$

By measuring the gap between equation (14) & formula (15), the power system loss reduction would be equivalent to:

$$\Delta Q_k = 2 I_{crk} \sum_{i=1}^{k} x_i I_{ri} - I_{crk}^2 \sum_{i=1}^{k} x_i \qquad (16)$$

This paper presents two methods of finding the optimal location of TCSC for IEEE-14, IEEE-33, and IEEE-57 bus test systems; Particle Swarm Optimization and Salp Swarm Algorithm, which are explained in the following headings.

E. Optimal Location using Particle Swarm Optimization (PSO)

Particle swarm optimization is based on a set of individuals originally arranged in a random and homogeneous manner, which we will henceforth call particles, which move in the research hyperspace and constitute, each, a potential solution.

Each particle has a memory concerning its best visited solution as well as the ability to communicate with the particles constituting its surroundings. From this information, the particle will follow a tendency made, on the one hand, of its will to return to its optimal solution, and on the other hand, of its mimicry compared to the solutions found in its vicinity [18].

From local and empirical optimums, the set of particles will, normally, converge towards the global optimal solution of the problem treated [19].

- A particle swarm is characterized by:
- The number of particles in the swarm, noted nb.
- The maximum speed of a particle, denoted $\vec{v}_{max}$
- The topology and size of a particle's neighborhood that defines its social network.
- The inertia of a particle, noted Ψ.
- The confidence coefficients, noted ρ_1 and ρ_2, which weight conservative behavior (the tendency to return to the best solution visited) and panurgism (the tendency to follow the neighborhood)

A particle is characterized, at time t, by:

$\vec{x}_i(t)$: at position in the search space.

$\vec{v}_i(t)$: its speed.

$\vec{x}_{pbest_i}$: the position of the best solution through which it went.

$\vec{x}_{vbest_i}$: the position of the best-known solution in its vicinity.

$pbest_i$: the fitness value of its best solution.

$vbest_i$: the fitness value of the best-known solution in the neighborhood.

Algorithm of PSO:

```
INPUTS: $0 < \rho < 1$
  repeat
      for $i = 1$ until $nb$ do
          if $F(\vec{x}_i) > pbest_i$ then
              $pbest_i = F(\vec{x}_i)$
              $\vec{x}_{pbest_i} = \vec{x}_i$
          end if
              $\vec{v}_i = \vec{v}_i + \rho(\vec{x}_{pbest_i} - \vec{x}_i)$
              $\vec{x}_i = \vec{x}_i + \vec{v}_i$
      end for
until (one of the convergence criteria is met)
```

F. Optimal Location using Salp Swarm Algorithm (SSA)

Salps belong to the family Salpidae and have a barrel-shaped body that is translucent. Its texture is somewhat close to jellyfish texture. They even move along, just like jellyfish [20], by moving water into their legs. Biological experimentation on these species is only the beginning point because of the complexity of these animals accessing their environments and maintaining them in a laboratory setting. Herd activity, which is the topic of this post, is the most important characteristic of salps. Salps also form several chains in the deep oceans, called salpa chains. The key explanation for this action is not yet clear, although some researchers assume that utilising increasingly organised improvements and food search methods [20], this is achieved to produce smoother movement.

Salpa chains demonstrate a statistical model of herd behaviour; it starts by splitting the community into two groups: a leader and a follower. To govern the herd, the leader is always in front of the chain, and the others obey him. In the search area, there is a specific food supply named TF that any herd targets. The equation for the Leader Salp location update by goal food source is as follows[20]::

$$x_j^1 = \begin{Bmatrix} TF_j + c_1\big(c_2(ub_j - lb_j) + lb_j\big) & c_3 \geq 0 \\ TF_j - c_1\big(c_2(ub_j - lb_j) + lb_j\big) & c_3 < 0 \end{Bmatrix} \qquad (17)$$

Here, x j^1 is the leading salpine location in the j^th dimension, ?? TF ?? j is the goal food source in the j^th dimension, c 1, c 2 and c 3 are random numbers, ?? ub ?? j and ?? lb ?? j, the upper and lower limits in the j^th dimension, respectively. The coefficient c 1 balances the testing space phases of discovery (global search) and exploitation (local search). It is therefore regarded as the most appropriate SSA algorithm parameter and is given in the following equation [20]:

$$c_1 = 2e^{-\left(\frac{4m}{M}\right)^2} \qquad (18)$$

Here, m is the current phase, while M is the cumulative number of stages. Let the value of M be equal to 100. Both are random numbers, in the range of c 1 and c 2[0, 1] coefficients generated uniformly. The position of each follower salpin is updated according to the path followed by the equation as follows [20]:

$$x_j^i = \frac{1}{2}\left(x_j^i + x_j^{i-1}\right) \qquad \forall i \geq 2 \qquad (19)$$

Equation (19) reveals that each salpin follows its leader to shape a chain of salps. Here, the j^th dimension i^th follower salpin location describes x j^i. As with other herd-based optimization algorithms [20], the starting positions of all salts are created randomly.

6. SIMULATION RESULTS

The graphs below represent the results obtained:

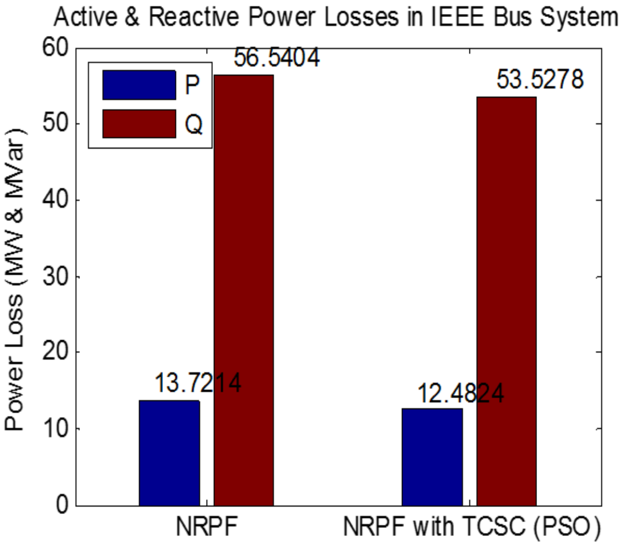

Figure 4: Active & Reactive power losses in IEEE-14 bus system using PSO

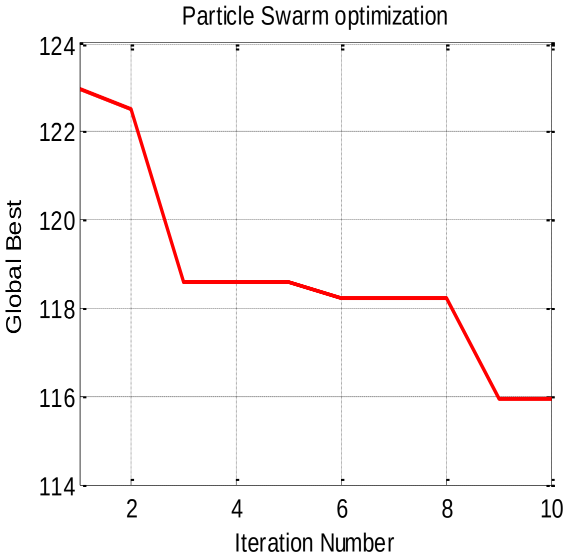

Figure 5: Particle Swarm Optimization iteration graph

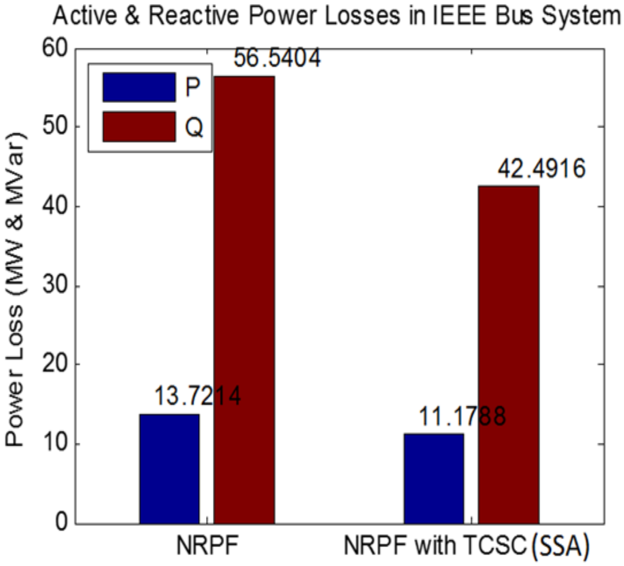

Figure 6: Active & Reactive power losses in IEEE-14 bus system using SSA optimization

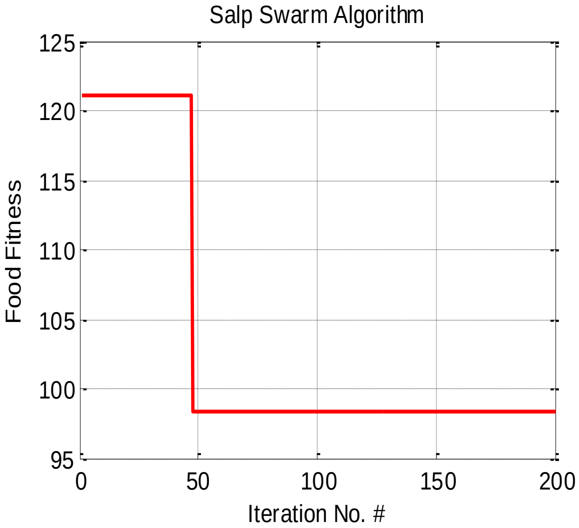

Figure 7: Salp Swarm Algorithm iteration graph

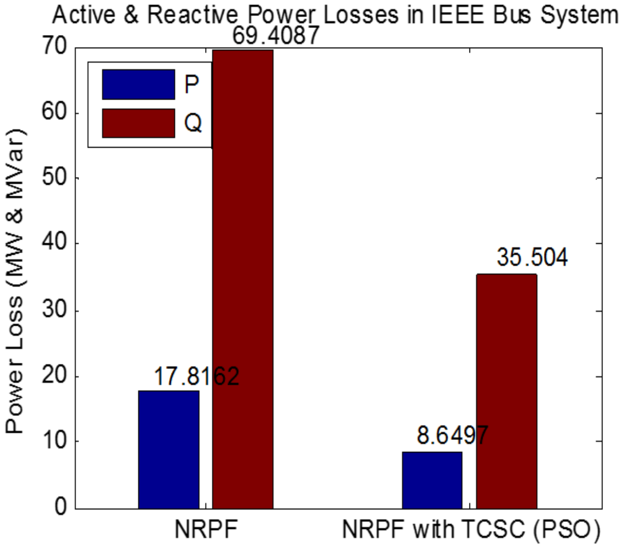

Figure 8: Active & Reactive power losses in IEEE-33 bus system using PSO

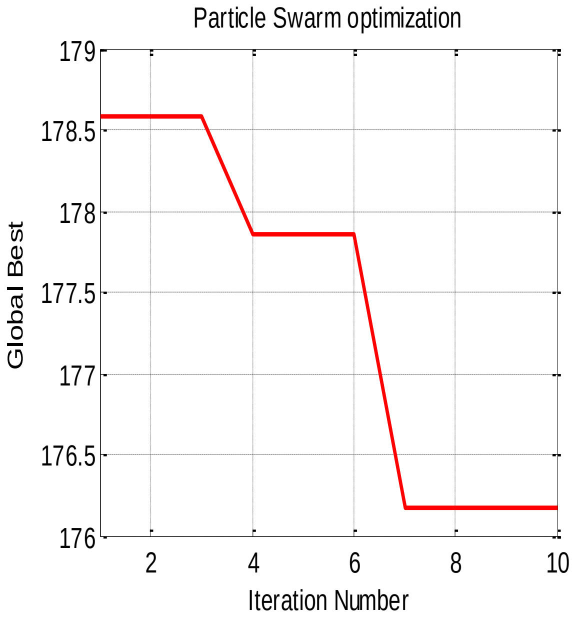

Figure 9: Particle Swarm Optimization iteration graph

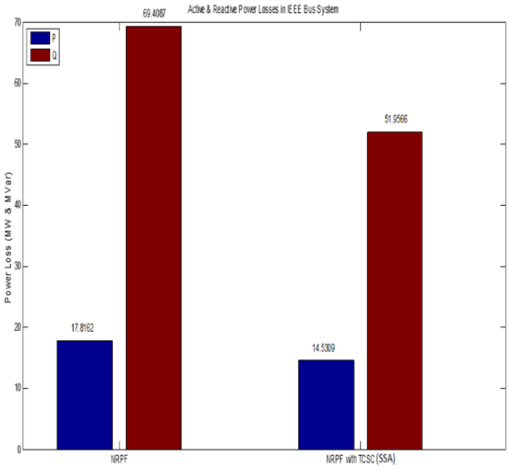

Figure 10: Active & Reactive power losses in IEEE-33 bus system using SSA optimization

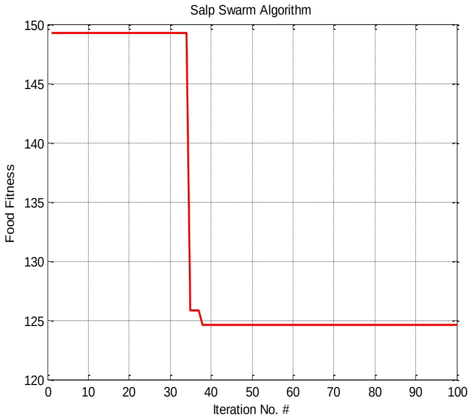

Figure 11: Salp Swarm Algorithm iteration graph

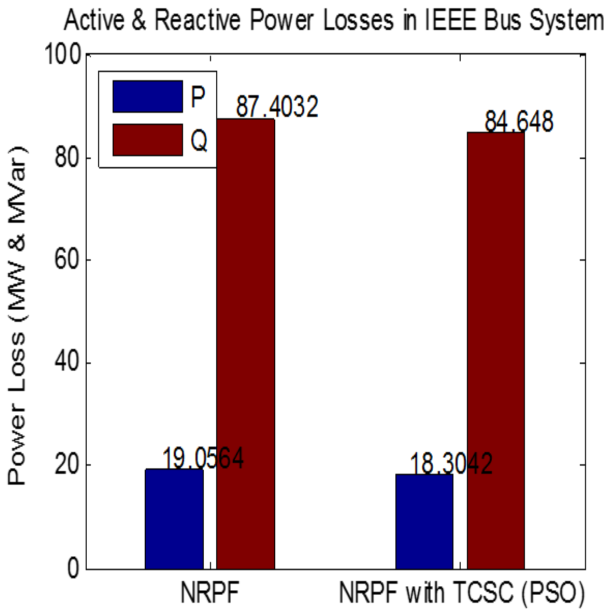

Figure 12: Active & Reactive power losses in IEEE-57 bus system using PSO

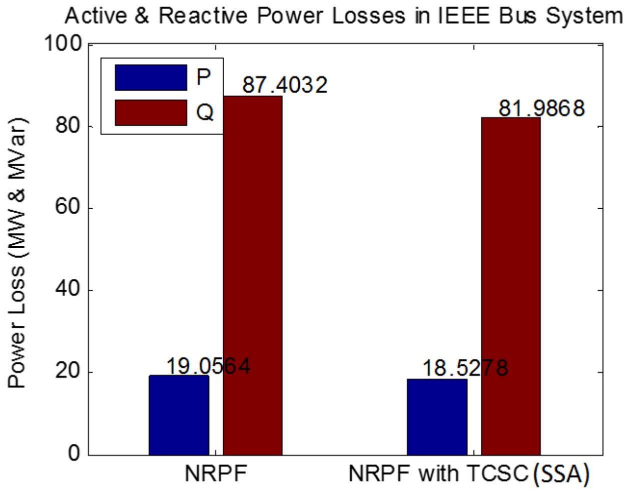

Figure 13: Active & Reactive power losses in IEEE-57 bus system using SSA optimization

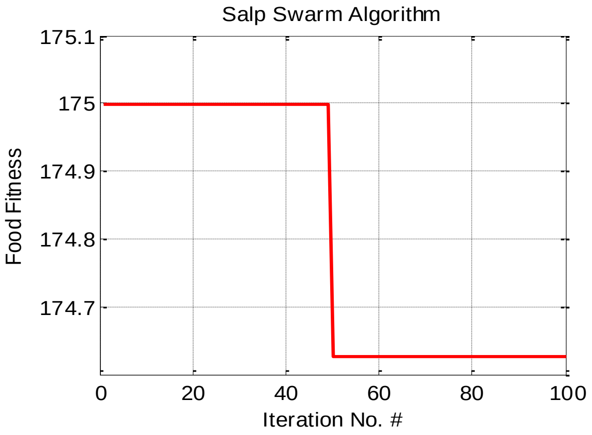

Figure 14: Salp Swarm Algorithm iteration graph

Table 1: Comparative analysis for active power loss and reactive power loss

Bus Test System	**NRPF**		**NRPF-TCSC-PSO**		**NRPF-TCSC-SSA**	
	Active power (MW)	**Reactive power (MVar)**	**Active power (MW)**	**Reactive power (MVar)**	**Active power (MW)**	**Reactive power (MVar)**
IEEE 14 bus test system	13.7214	56.5404	12.4824	53.5278	11.11788	42.4916
IEEE 33 bus test system	17.8162	69.4087	8.6497	35.504	14.5309	51.9566
IEEE 54 bus test system	19.0564	87.4032	18.3042	84.648	18.5278	81.9868

7. CONCLUSION

Reactive energy compensation is an essential operation that generates not only technical benefits but also economic gains. It is carried out by introducing one of the FACTS devices which are the most efficient, or capacitors connected via circuit breaker which are slower but they have proven their efficiency in an industrial environment. They include global or individual compensation as needed. The optimum sizes of the batteries are determined in such a way that they make the economic cost or return function maximum. In this objective function, the reduction of the reactive power losses has been introduced because the installation of the batteries reduces not only the active power losses but also the reactive losses. Since the batteries are installed one after the other, the optimum power determined by deriving the objective function is only an initial value from which is determined a standard size available on the market which satisfies the constraints of the problem namely a reduction of the positive power losses and reactive current of positive branch load. This last constraint comes to replace the stress on the tension which cannot lead to a solution if small limits are considered. The MATLAB environment is used for this comparative study to model and simulate. A performance analysis for the optimal location of TCSC was made by using PSO and SSA algorithms. The results show that the Salp Swarm Algorithm is the best performing compared to Particle Swarm Optimization devices.

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