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TCSC Placement Problem Solving Using Hybridization of ABC and DE Algorithm

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***Abstract*: Flexible Alternating Current Transmission Systems (FACTS) devices represents a technological development in electrical power systems to have a tendency to generate the power with minimum price and less time that fulfill our requirement according to our need. Now a days Flexible AC Transmission System (FACTS) devices play a vital role in boost the power of system performance and power transfer capability. TCSC is an important member of family. In practical TCSC implementation, several such basic compensators may be connected in series to obtain the desired voltage rating and operating characteristics, so its placement is very important. This paper represent a meta heuristic hybrid Algorithm of Artificial Bee Colony (ABC) and Differential Evolution (DE) for finding the best placement and parameter setting of Thyristor Controlled Series capacitor to attain optimum power flow (OPF) of grid network. The proposed technique is tested at IEEE-30 bus test System. Result shows that the selected technique is one of the best for placement of TCSC for Secured optimum Power Flow (OPF).**

***Keywords:* Optimal placement, Severity index, stressed power system, System loadability, TCSC, Hybrid DE/ABC.**

I. INTRODUCTION

FACTS devices have been used for solving various power system issues like voltage stability, power flow control, and transfer capability etc. The FACTS concept was initially outlined by N.G. Hingorani, in 1988. According to IEEE definition, it is Alternating current transmission system incorporating power electronic based and other static controllers to enhance controllability and increase power transfer capability. [1]

FACTS devices such as Thyristor Controlled Series Compensator can help increase power transfer capacity in heavily loaded network because of its capability to control power flow flexibly. In a multi-machine network, the influence of TCSCs on the network is complex since the control of any one device influences all others,In a competitive (deregulated) power market, the location of these devices and their control can significantly affect the operation of the system. Optimal allocation and control of these devices will be very important. Use of TCSC to maximize Total Transfer Capability generally defined as the maximum power transfer transaction between a specific power-seller and a power-buyer in a network.[2]

Flexible Alternating Current Transmission Systems (FACTS) devices is an important parameter in electrical power systems, which makes utilities able to control power flow, increase transmission line stability limits, and improve security of transmission systems. In addition, FACTS devices can be used to maximize power transfer capability and minimize transmission system power loss, leading to an efficient utilization of existing power systems. However to what extent the performance of FACTS devices can be brought out highly depends upon the location and the parameters of these devices. In this, we propose one of the newest Evolutionary Optimization Techniques, namely Differential Evolution (DE) to select the optimal location and the optimal parameter setting of TCSC which minimize the active power losses in the power network, and compare it is performances with Genetic Algorithm (GA). [3]

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In deregulated power systems, total transfer capability (TTC) analysis is presently a critical issue either in the operating or planning because of increased area interchanges among utilities. FACTS devices can be an alternative to reduce the flows in heavily loaded lines, resulting in an increased transfer capability, low system loss, improved stability of the network, reduced cost of production and fulfilled contractual requirement by controlling the power flows in the network. It is important to ascertain the location for placement of these devices because of their considerable costs. A method to determine the suitable locations of thyristor controlled series compensators (TCSC) and thyristor controlled phase angle regulators (TCPAR) based on the real power flow performance index sensitivity has been suggested, for enhancing the total transfer capability of the interconnected power system. A conceptually reasonable and computationally feasible approach has been developed. [4]

Considers the placement of Flexible AC transmission system devices into power systems with a criterion of maintaining a prescribed level of control reconfigurability. Control reconfigurability is measures the small signal combined controllability and observability of a power system with an additional requirement on tolerance to loss of measurement data in any single measurement unit in the system, which have not been considered in the existing works. Control device placement is formulated as an optimization problem of finding a minimum number of new control devices to meet a prescribed control reconfigurability threshold. A binary search algorithm and a genetic algorithm are applied to Thyristor Controlled Series Compensators into a number of IEEE test systems. [5]

A genetic-algorithm (GA) based OPF algorithm for identifying the optimal values of generator active-power output and phase shifting purpose. The locations of phase shifters are selected based on sensitivity analysis. To overcome the shortcomings associated with the representation of real and integer variables using the binary string in the GA population, the control variables are represented in their natural form. Also crossover and mutation operators which can deal directly with integers and floating point numbers are used. Simulation results on IEEE 30-bus is presented and compared with the results of other approaches. [6]

With the interconnection of the large regional power grid and the establishment of the future electricity market, since the grid power flow randomness and the probability of transmission congestion occurred greatly increased, transmission congestion has become more serious that affects the safe and stability of the modern power grid, which is bad for the efficient and economical operation of electricity market. How to solve the transmission network congestion problem have become forefront topics at the field of electricity market. In the traditional vertical management mode, once the transmission power exceeds the limited case, the dispatch center schedules independently according to certain principles, which is different from the electricity market environment. The electrical energy is circulated by electricity trading. The economic interests of all market participants is involved in eliminating the congestion process, meanwhile, eliminating congestion requires not only the technical support, but also the consideration of the justice and benefits, which makes the congestion problem more complicated. Elimination of congestion mainly uses two types of technical and economic methods. The former mainly relies on the advanced and reasonable scheduling means (e.g. FACTS controlling technology), the latter mainly uses the price mechanism.[7]

II. TCSC PLACEMENT PROBLEM

A. TCSC:

A TCSC can be defined as a capacitive reactance compensator which consists of a series capacitor shunted by a Thyristor controlled reactor in order to provide a smoothly variable series capacitive reactance.

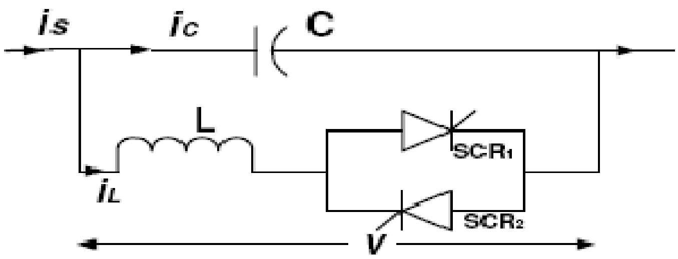

Fig 1 TCSC configuration

B. Placement problem:

There is a troublesome task to perform optimum placement of TCSC because of high price of TCSC but it is necessary to find out the precise location of device. There is no, to the simplest of author's data, paper that suggest a straight forward and reliable technique for determinative the suitable location of FACTS devices with static issues. Several factors depend on the situation of the device. optimum Power Flow (OPF) for reactive power planning could be a static nonlinear programming downside aimed at programming the controls of the facility of system in an exceedingly manner that optimizes an explicit objective perform whereas satisfying a collection of physical and operational constraints imposed by instrumentation limitations and security needs [8].

III. METAHAURISTIC METHOD

A. Differential Evolution:

A basic variant of the DE algorithm works by having a population of candidate solution (called agents). These agents are moved around in the search-space by using simple mathematical formulae to combine the positions of existing agents from the population. If the new position of an agent is an improvement it is accepted and forms part of the population, otherwise the new position is simply discarded. The process is repeated [9].

Step 1: Initialize a set of population members randomly.

Step2: Evaluate the fitness (objective value) for each population member and record the best fitness and member.

Step3: Shuffle the population into a number different sets to make the differential variations of the whole population.

Step4: From the populations in *Step3*, select one to be 'base vector' population and determine the 'weighted difference' population from other two sets of population, then add the base vector and weighted difference vector together to obtain the 'mutant population'

Step5: Crossover operation between the initial population and the mutant population by randomly replacing the initial population with the mutant population at the crossover probability

Step6: Evaluate fitness of the mutant vectors, compare with that of the initial population and replace some of population members by the better vectors obtained

From *Step5*

Step7: Record the best member found so far

Step8: Repeat *Step2* to *Step7* until one of the stopping criteria is met. The criterion is either the maximum number of generations or the target value of the best fitness. The solution to the problem is the recorded member from Step7

B. Artificial bee colony:

The artificial bee colony algorithm (ABC), a relatively new meta-heuristic algorithm based on the social behavior observed in honey bee swarm, was introduced in 2005 by Karaboga as a solution to the optimization problem with multivariable functions. It is based on the observation made on the social behavior of the honey bee swarm.

The artificial bees are classified into three categories:

1. *Employed bees:* Each artificial employed bee is attached to a single food source. It has two functions: exploit this food source, and advertise its position, by dancing in the hive, to attract more artificial onloooker bees to further exploit this food source.

2. *Onlooker bees:* The artificial onlooker bees tend to chose the best food source to exploit. As such good food sources attract more artificial bees, thus get more exploited.

3. *Scout bees:* When a given food source has been exhausted, its employed bee will be converted to a scout that will chose a random new food source to exploit. A food source represents a possible solution to the considered optimization problem, while its quality represents the fitness of the solution.

The artificial bee population is evenly divided by the artificial employed bees (*SN* artificial bees) and the artificial onlooker bees (*LN* artificial bees).

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C. Proposed method:

Here we are using somewhat different terminology i.e. hybridization of artificial bee colony (ABC) and Differential algorithm (DE) [10].

(1) Initialize the population of solutions $X_{i,j}$

(2) Population is evaluated.

(3) For cycle = 1; REPEAT

(4) New solutions (food sources positions) $Y_{i,j}$ in the neighbourhood of $Y_{i,j}$ are produced for the employed bees (ne) using $Y_{i,j} = X_{i,j}$ +rand (i j) $*$ $(X_{i,j} - X_{k,j})$ (k is the solution in the i^{th} neighbourhood, rand (i j) being a random number in $-1 \leq$ rand ≤ 1) and evaluate them

(5) Store the best values between $x_{i,j}$ and $v_{i,j}$after greedy selection process

(6) Probability values P_i for different solutions of X_i are calculated by means of their fitness values using equation

$$P_i = \frac{F_i}{\sum_{k=1}^{fs} fit_k}$$

Here F represents the fitness values of solutions and these are calculated by using

$$fit_i = \frac{1}{1+f(X_i)}$$

Then after P_i values are normalized into [0, 1]

(7) Based on the probabilities P_i, new solutions V_i for the onlookers are produced from the xi

(8) REPEAT Step-5

(9) Next, the abandoned solution (position or source) is determined if exits, and it is replaced with a newly produced random solution X_i for the scout as explained in scout bee phase i.e., using $X_{i,j} = lb_j$ +r $*$ $(ub_j - lb_j)$

(10) Memorize the best food source solution obtained so far (11) cycle = cycle+1

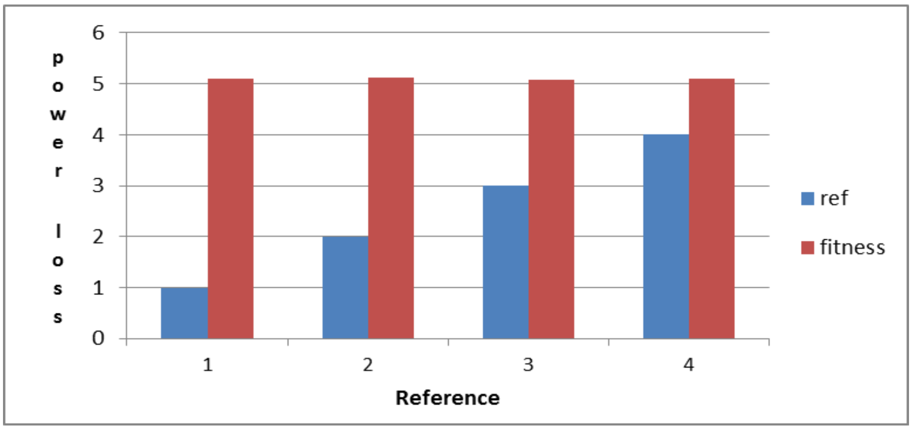
(12) Until cycle = Maximum;

(13) stop.

IV. RESULT

From the whole analysis, we obtain that as we increase the reference value primarily the power loss is increases in case of DE but after that it decreases and that point is the best location of TCSC placement.

Ref	1	2	3	4
Power Loss	5.0864	5.0905	5.0898	5.0864



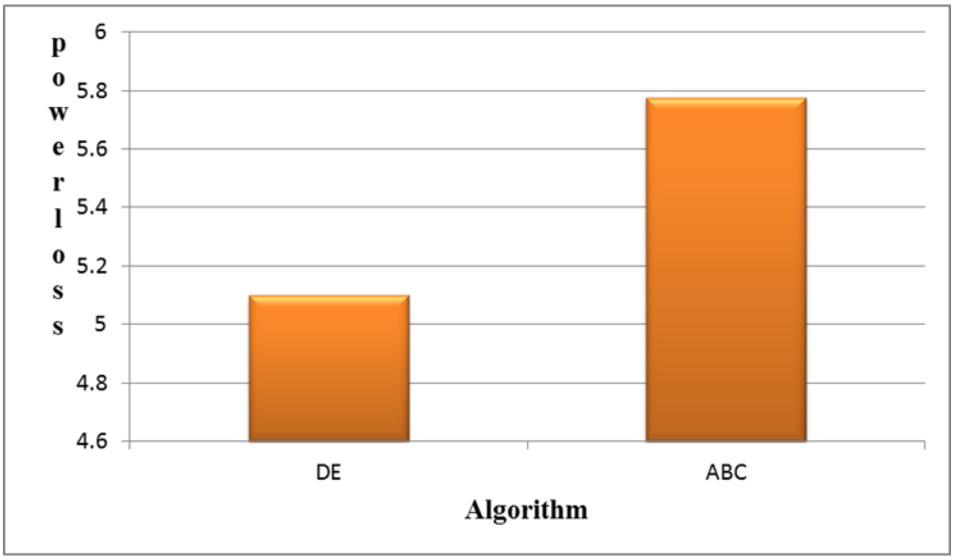
But from the ABC analysis as we increase as the number of iteration, power loss is same in all the case.

Ref	1	2	3	4
Power Loss	5.7763	5.7763	5.7763	5.7763

From the whole analysis it is clear that hybrid of ABC and DE give best result for TCSC placement. DE gives the minimum power loss and ABC maintain the power loss to be constant.

Below graph showing the combine analysis of both Algorithm.

Algorithm	Power Loss
DE	5.0996
ABC	5.7763



V. CONCLUSION

The effectiveness of the best installation of FACTS for minimizing the active power generation price in power system is investigated. TCSC is reactance control FACTS device which may manage power flow between the lines. To indicate the effectiveness of the projected methodology standard take system (IEEE 30 bus) is employed for simulation study. Simulation results reveal that the projected algorithmic rule works satisfactorily for the system sat at rated load. Moreover, it will be inferred from the simulation results that installation of TCSC will scale the transmission loss and improve the ability flow through the transmission line at reduced generation price for all the techniques mentioned.

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