ABSTRACT

All issues from financial aspects to designing require some sort of optimization as the accessibility of assets in terms of time, cash and vitality are constrained. Engineering design problems become complicated when transformed into a scientific shape and hard to be explained by using established numerical strategies. Heuristic methods were thus developed to address specific problems, however not ensuring ideal outcomes, but provide a sensible result in a reasonable amount of time. Metaheuristic algorithm, a variant of heuristic, is an arrangement of guidelines that can be connected heuristically to most engineering problems. These algorithms have provided a noteworthy change in the field of computation by handling data that are uncertain and contain fractional truth.

The metaheuristic techniques comprises of two segments: Diversification - Investigating the search space for new conceivable solutions and Intensification - Exploiting the nearby locale of regions that have received spotlights through exploration. Incorporation of random numbers, motivation from nature and tuning parameters are the common attributes of these algorithms. Random numbers make the algorithm investigate new solutions but may produce contradicting results many times. Careful choice of tuning parameters is a serious concern as it significantly determines the quality of solutions produced. After a cautious investigation of these confinements, a new metaheuristic algorithm titled "Deterministic Oscillatory Search (DOS)" has been proposed.

As soft computing techniques cannot be considered a panacea, the algorithms have been carefully tested using benchmark mathematical functions and a power system problem involving Flexible AC Transmission System (FACTS) devices. Power system problem is chosen as a validation tool based on the critical need to enhance the present power system environment. This thesis explores the application of FACTS devices in upgrading the power system network and presents the criteria for the choice of FACTS device for the issue under review. A detailed methodology to appropriately locate FACTS devices in the power system during normal and contingency periods has been demonstrated.

The DOS algorithm proposed is computationally feasible, quick and autonomous to the problem under study. The motivation to develop the algorithm with these characteristics has been from the impediments observed from the existing algorithms. A combination of the gradient and swarming technique is applied to obtain results better that the existing metaheuristic algorithms that mostly rely on swarming behaviour. Another favourable trait of DOS is that the calculations have to be assessed only once to obtain the solution to a problem, in contrast to other algorithms which are assessed for a few numbers of trials. To legitimize these theories, the algorithm is evaluated using 16 functions comprising of varied modalities, linearity, and minima. It has been observed to solve problems regardless of the number of solutions.

To supply the electrical energy demand without exceeding thermal limits and maintain stability, high-speed FACTS devices are installed in the power system network. They are exceedingly utilized in the power system to enhance voltage stability and power transfer capability. Nevertheless, the upsides of FACTS devices can be completely restrained with the identification of appropriate size and installation sites for these devices. Choice of FACTS devices has been a convincingly powerful decision as each device has its own characteristic and improves one or more of the vital power system problems. Based on detailed examination of the literature aided with simulation studies, STATCOM and UPFC have been chosen for further study.

After choosing the FACTS devices based on the objectives, the process of finding the size and location is accomplished using various algorithms and the proposed DOS algorithm. VCPI index, Voltage deviation, and real power loss are chosen as objectives as they are noteworthy concerns in the power system environment. The index is basic and simple to ascertain and henceforth can be used for on-line observation of the system. The problem is formulated mathematically alongside limitations and validated using three benchmark power systems: IEEE 118, IEEE 39 and the Indian Uttar Pradesh State Electricity Board system. The proposed algorithm is tested under three situations, one with the installation of STATCOM, one with UPFC and the third with both STATCOM and UPFC. The results obtained signify the effectiveness of the proposed algorithm in comparison with the existing algorithms like PSO, BAT, ABC and MABC under normal and overloaded conditions.

As the power system network is highly intricate and interconnected with many devices, even a small disturbance may lead to extreme casualties and frailty in the system. This mandates the need to test the effect of FACTS devices in the power system during contingencies. Improvement in the power system environment after placing the FACTS devices at suitable locations during various single line contingencies is demonstrated. As in the previous case, three standard test cases and three situations are used as a validation tool to determine the effectiveness of the proposed algorithm. DOS algorithm is able to find the best location and size of FACTS devices in terms of Z index (average loadability) and real power loss compared to PSO, BAT, ABC and MABC paradigms.

Overall, it is evident that the proposed algorithm can solve complex engineering problems successfully. It is also to be noted that installation of multiple types of FACTS devices can improve the performance of the power system in terms of voltage stability and real power losses during normal and emergency states. By and large, a significant contribution has been made for the benefit of the society in providing quality energy.