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Application of Nature Inspired Search Based Optimization Techniques in a Restructured Electric Power System; a Review

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ABSTRACT*: In recent years large numbers of algorithm based on nature inspired optimization techniques have been proposed by various researchers in the field of power system engineering. In this regard this paper reviews the need to use these approaches in solving problems of an electric power system. Nowadays, there is no investment in power business without the hope of return and there is no energy supplied if it is profitable. This is why many researchers in the field of electrical power system are looking out for better optimization techniques as a way out to deal with the problems domiciled in the industry. Different types of natured inspired optimization approaches to tackle electric power system challenges has been reviewed and compared with traditional optimization methods. A major part of nature inspired algorithms are based on biological system and some are developed by using inspiration from physical and chemical system. Some also may be based on music.*

Keywords: *Electricity Market; Economic operation; Nature-inspired approaches; Traditional techniques; Restructured Electric Power system*

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I. INTRODUCTION

The nature of optimization problems in Engineering are becoming more complex, researchers and scientists are giving more importance to alternate programming techniques which are more robust and efficient than the traditional optimization techniques. The electric power industry is passing through a wholesome revolution worldwide. Market forces, scare natural resources and an ever increasing demand for electricity are some of the drivers responsible for such an unprecedented change. The economic operation of power system is the watch word nowadays [1]. Researchers in the field of electric power system engineering have demonstrated ample interest in these nature inspired optimisation methods. The techniques have been greatly applied in solving power system engineering problems such as: solving Economic Dispatch Problems with Generator Constraints, design of optimal Power System Stabilizer, optimal reactive power dispatch problem, load frequency control of large scale power system, optimal location and Parameter settings of FACTS Devices in Power Systems, optimal PSS Design in a Multi-machine Power System, optimal power flow solution in power systems, Transmission Network Expansion Planning, optimal design of PID controller, For solving unit commitment problem, Optimal Allocation and Sizing of Multi Distributed Generation, Multi-Objective Reconfiguration of Distribution Systems, Real Power Losses minimisation, Robust Design of Power System Stabilizers, Solving Power system stability problems, Maximum Power Point Tracking (MPPT) for PV system, Effective Detection of Inrush and Internal Faults in Power Transformers, Reactive Power Pricing in an Open Electricity Market etc. The list is endless [2]. In this paper, the review of application of nature inspired search based optimization techniques in a restructured electric power system is presented. Other contents of the paper are structured as follows; in Sections 1, challenges of a restructured electric power system is emphasized, sections 2, a brief comparison of traditional optimisation methods and nature inspired optimisation techniques is highlighted, sections 3, classification of nature inspired algorithms in power system optimisation is discussed in detail and finally, conclusion is provided in Section 4.

1.1 Challenges of a Restructured Electric Power system

The persistent increase in demand for electricity has created so many problems for power systems investors and engineers such as power system security issues, power system losses, transmission lines overloading, voltage deviation, and stability margin reduction and so on [3]. Nowadays, Power system structure has moved away from monopoly (Government owned) to deregulation philosophy (Private sector driven). The deregulation philosophy broke the before monolithic power sector into distinct parts, as generators, transmission, distribution, trader, etc. In the deregulated environment the profit is the only driver and watch word. There is no investment without the hope of return and there is no energy supply if it is not profitable. Therefore, the management of the modern power system faces mainly optimization tasks. The tasks include: **Decision making:** Decision making at inception of power system project is key to the successful execution of the project. To develop a large or small hydro power station or Thermal power station or Renewable energy power station or Power transmission or distribution network is not an easy question to ask? Any wrong decision means that optimal market condition will not be met. There is no good or bad choice but all the choices have effects on dozens of different aspects. Heuristic optimisation technique can be developed using qualitative function as weighting methodology and a key indicator to ascertain if optimal market condition will be achieved or not. Social aspects, Technological, Economic, Political, Legislation and Environmental aspects have to be taken into consideration in optimisation especially when it is beyond the capability of analytical methods. [4, 5].
1.11 **Optimization of the schedule of renewable energy sources:** Integrating different renewable energy mix such as wind, solar, geothermal power plants into the conventional grid will be in such a way that minimal cost is achieved with maximum profit. The size of each energy mix and their battery capacity are optimal determined with nature inspired optimisation techniques to achieve the desired market condition such as maximum or minimum load delivered to the customers depending on what is needed[6, 7].

1.12 Energy storage problems: In the energy market the players are the generators, transmitter, distributors, and consumers and trader entities. The deal is the profit maximization. If a generation company has renewable generation capability and also storage possibility it is hard to say, when to store the energy and when to sell directly to the market. Nature inspired optimisation techniques can be used to develop a rule based intelligence system to make decisions when to sell/buy/store power in function of renewable production possibility and market price. [8, 9].

1.13 Optimization of the network structure: The "Smart" network means that there are renewable sources, adaptive protections, intelligent controllers, on-the-line switches, intelligent meters, on-the-line metering devices, etc. But how many smart devices should be built in the network? This is achieved optimally through natured inspired optimisation techniques. Reliability can be increased by building in primary and secondary gauges, remotely controlled line breakers, redundant network parts or reconstructing parts of the old network. These measures have different costs and results. Detailed optimisation techniques using natured inspired methodologies will bring the best option with cheaper cost and maximum profit [10, 11].

II. TRADITIONAL OPTIMISATION METHODS VERSUS NATURE INSPIRED OPTIMISATION TECHNIQUES

Traditional optimisation methods can be divided into two groups namely:
2.1 Classical Optimization Methods: These techniques are based on mathematical formulation which result in solution(s), usually in an iterative process and can be divided into linear programming (LP), nonlinear programming (NLP), integer programming (IP), mixed integer linear programming (MILP), mixed integer nonlinear programming (MINLP), quadratic programming (QP), and dynamic programming. Advancements have been made with classical methods, but they suffer from following disadvantages that make their usage in power system optimization perverse and forbidding. They do not guarantee reaching to global optima, especially because they start from a single point, not a population, it is likely that they converge to local optima, When the size of the problem increases, solution process becomes so difficult and in some cases, it will have convergence problems. (curse of dimensionality), these methods usually require problem knowledge which in some cases is not available, most often, these methods need some requirements such as continuity, differentiability of objective function and convexity of problem, whereas in most cases the problem does not meet these requirements [12].

2.2 Another traditional method used in power system optimisation are those based on technical criteria such as **sensitivity analysis** for steady state and **modal analysis** for transient and dynamic optimization problems. The basis of sensitivity analysis methodologies is deficient in the formulation and implementation of an appropriate search process especially when the size of the problem increases. The disadvantages of modal

analysis are their complexity and the need to compute large matrices; also they do not guarantee optimality of the solution [13 and 14].

2.3 Heuristics or Nature Inspired Optimisation methods: The real-world problem is very challenging. So, it cannot be solved optimally by using traditional methods. In recent times researcher's studying on various kind of Meta heuristics algorithm such as elephant herding optimization (EHO), artificial bee colony, particle swarm optimisation, genetic algorithm etc. have successfully applied them to solved number of problems of real world. Meta-heuristic Search Based Optimisation Techniques are approaches which seek optimal or near optimal solutions at a reasonable computational cost, which are usually population-based, stochastic-based and inspired by chemical, biological or human intelligence phenomena. Several Nature Inspired computation techniques and their hybrid versions can be used to address all power system problems but the results are highly dependent on the nature of the problem and the implementation of the algorithm. [3, 15].

III. CLASSIFICATION OF NATURE INSPIRED ALGORITHMS IN POWER SYSTEM OPTIMISATION

Nature Inspired algorithm can be categorised into four major groups namely: Swarm Intelligent (SI) based, Bio inspired (but not SI based), Physics/Chemistry based and others.

3.1 Swarm Intelligence based algorithms: The philosophy is based on the use of use of multi – agents, inspired by the collective behaviour of social insects and flocks of birds and fish. These techniques are among the most popular and widely used in power system optimisation.

The author in his work demonstrated that Search group algorithm and fire fly algorithm techniques can be used to tune PID controller parameters to improve automatic generation gain controller in a two-area six-unit power system. It was confirmed that PID controller offers significant improvement in the response when compared to the FA tuned PID controller. It was proved beyond reasonable doubt that the proposed SGA optimized PID controller is much more effective, robust and furnish best system performance as comparison to FA tuned PID controller [16].

The author proposed the use of Particle Swarm Optimization (PSO) algorithm to obtain optimal settings of TCSC for the improvement of available transfer capability on power transmission network and the results obtained are quite encouraging. The work was carried out on sample 6 bus and IEEE 30 bus systems. The considerable difference between ATC values with and without TCSC justifies that the FACTS technology can offer an effective and promising solution to boost the usable power transfer capability, thereby improving transmission services of the competitive electricity market [7].

The author in his work proposed a hybrid algorithm which combines PSO and GA to site SVC optimally in a power network. It was shown that the new algorithm is more effective and efficient. This was validated using IEEE 68 bus test system. In this new algorithm the author had tried to forestall the drawbacks of PSO and GA and thus form a better algorithm. This algorithm is suitable for solving any optimization problem in an electrical power system [18].

The author in his work developed Particle Swarm Optimization (PSO) based algorithm to obtain the maximum instantaneous wind penetration by adjusting the grid parameters and FACTS controller settings. The developed algorithm was tested on modified IEEE 14-bus test system. The results obtained are promising when tested on IEEE 14-bus system. SVC FACTS device was used to achieve this technique [19].

PSO optimization technique was proposed by the authors to design the PSS and UPFC controllers individually to damp out low frequency oscillations in a weakly connected system. This technique was utilized to search for the optimal controller parameter settings that optimize an eigenvalue-based objective function. The potential of the UPFC controllers to enhance the dynamic stability is evaluated by measuring the electromechanical controllability through singular value decomposition (SVD) analysis. The effectiveness of the proposed controllers on damping low frequency oscillations is tested through eigenvalue analysis and non-linear time simulation and the test was very promising[20].

The author proposed a technique called quasi oppositional grey wolf optimization algorithm (QOGWO) for the first time to solve load frequency control problem (LFC) of a power system. It was used to designed optimal proportional-integral-derivative controller (PID) employing integral time absolute error (ITAE) based fitness function. Two-area hydro-thermal and four-area hydro-thermal power plant test systems are considered to confirm the potentiality and effectiveness of proposed QOGWO algorithm tuned PID in terms of fitness value, overshoot, undershoot, setting time of system oscillations. Also, sensitivity analysis show that the optimized QOGWO based PID-controller is quite robust and gives satisfactory performance under uncertainty. QOGWO tuned PID performs better than other intelligent tuned PID controllers such as fuzzy logic, artificial neural network (ANN) and adaptive neuro-fuzzy interface system (ANFIS), this is confirmed by time domain simulation [21].

The author proposes the use of oppositional grey wolf optimization (OGWO) algorithm for resolving the optimal operating strategy of economic load dispatch (ELD) problem. The algorithm is validated using small, medium and large scale test systems for solving ELD problems of 13-unit, 40-unit and 160-unit systems. The simulation results clearly suggest that the proposed OGWO approach is capable of finding better solutions in terms of computational time and fuel cost than the other technique that was compared with it such as GWO. Various nonlinearities like valve point effect prohibited operating zone and ramp rate limits are considered in the experiments [22].

A new intelligent algorithm known as firefly OPF algorithm was proposed by the authors to find best location and size of STATCOM. The algorithm was implemented for finding optimal location and sizing of STATCOM for voltage profile improvement in a benchmark IEEE 30-bus system. The results show that firefly OPF algorithm provides better global optimal solution for the optimal power flow with STATCOM. Voltage profile improved impressively, with much reduced transmission line loss [23].

Cuckoo Search (CS) algorithm has been proposed by the authors and has been successfully applied to solve both power flow optimal and optimal power flow incorporating FACTS devices. This algorithm which is one of the recent heuristic algorithms for solving optimization problems has several advantages including its few control variables, fast results, easy using process and simple structure. The proposed algorithm is tested on IEEE 9 bus test power system to demonstrate its effectiveness. The simulation results indicate the robustness of the proposed approach to solve the OPF problem of power systems with and without FACTS. It is observed that the FACTS devices (STATCOM and SVC) can reduce the transmission losses, voltage deviation and the fuel cost[24].

Bat algorithm technique was proposed to optimise the operating cost of a thermal power plant. The optimal solution of economic load dispatch (ELD) is obtained using the proposed bat algorithm. Numerical results show that the proposed method has good convergence property and better in quality of solution than PSO and IWD reported in recent literature. The main advantage of the proposed technique is easy of implementation and capable of finding feasible near global optimal solution with less computational effort. BAT Algorithm is easy to implement and priory in terms of accuracy and efficiency compared to other algorithms. In order to illustrate the effectiveness of the proposed method, it has been tested on 3 and 6-unit system. The proposed algorithm had been successfully applied to ELD with valve-point loading effect and included a few constraints [25].

The authors in their work propose Bacteria Foraging Optimization Algorithm (BFOA) based Static Var Compensator (SVC) for the suppression of oscillations in a multi-machine power system. The proposed design problem of SVC over a wide range of loading conditions is formulated as an optimization problem with an eigenvalue based objective function. BFOA is employed to search for optimal controller parameters. The performance of the proposed technique has been evaluated with the performance of Genetic Algorithm (GA) to demonstrate the superior efficiency of the proposed BFOA in tuning SVC controller. Simultaneous tuning of the Bacteria Foraging based SVC (BFSVC) gives robust damping performance over a wide range of operating conditions in compare to optimized SVC controller based on GA (GASVC) [26].

Modified Monkey optimization (MMO) algorithm was proposed by the author for solving optimal reactive power dispatch problem. MMO is a population based stochastic meta-heuristic algorithm and it is inspired by intelligent foraging behaviour of monkeys. The proposed (MMO) algorithm has been tested in standard IEEE 30 bus test system and simulation results show the worthy performance of the proposed algorithm in reducing the real power loss. [38] **27**

The authors in their work proposed Monkey Search Algorithm for solving the renewable energy integration problem considering various renewable energy sources. The final solution to the renewable energy integration problem includes three major parts: system models for PV system, wind system and diesel generator. The optimal number and type for each component in the system is calculated in such way that the total system cost is minimized subject to the restriction that the load requirements are completely met.[28].

A discrete monkey algorithm (DMA) was proposed by the authors for solving transmission network expansion planning problem. It includes limb process, watch-jump process, cooperation process, and somersault process, stochastic perturbation mechanism and termination criteria. The proposed method is applied to a 18-bus system and the IEEE 24-bus system. Numerical results demonstrate that DMA has powerful computational capability and is capable of solving different dimensions of expansion planning problems efficiently with small population size [29].

3.2 Bio – inspired but not SI based algorithms: Many bio-inspired algorithms do not use directly the swarming behaviour. They are named bio-inspired but not SI based.

The author presented an Elephant Herding Optimization Technique to design a PID controller for load frequency control (LFC) of a two-area hydro-thermal power plant. The prototype of hydro-thermal power plant with PID controller is simulated in MATLAB/SIMULINK platform. The PID controller parameters are

designed using this technique optimization under the minimization of error. The effectiveness of the proposed methodology is better in terms of settling time, rise time, peak and peak time. The parameters of PID controllers are tuned by Elephant Herding Optimization for solving the load frequency problem [30].

The author proposed a new technique called Brainstorm optimisation algorithm (BSOA) to find optimal location and setting of FACTS devices. Static var compensators (SVC's) and thyristor controlled series compensators (TCSC's) are used as FACTS devices. FACTS allocation problem is formulated as a multi-objective problem whose objectives are voltage profile enhancement, overload minimisation and loss minimisation. The results of applying BSOA to FACTS allocation problem in IEEE 57 bus system show its high efficacy in solving this problem both with TCSC and SVC units. BSOA is a novel promising heuristic optimisation algorithm inspired by brainstorming process in human beings. The findings of this research can be used by power system decision makers in order to establish a better voltage profile and lower voltage deviations during contingencies [31].

The author presented an algorithm called symbiotic organisms search (SOS) algorithm, for the parameter extraction of solar cell models. Extracting accurate values for relevant unknown parameters of solar cell models is vital and necessary for performance analysis of a photovoltaic (PV) system. SOS, inspired by the symbiotic interaction ways employed by organisms to improve their overall competitiveness in the ecosystem, possesses some noticeable merits such as being free from tuning algorithm-specific parameters, good equilibrium between exploration and exploitation, and being easy to implement. Three test cases including the single diode model, double diode model, and PV module model are served to validate the effectiveness of SOS. It is also compared with some well-designed parameter extraction methods. Experimental results in terms of the final solution quality, convergence rate, robustness, and statistics fully indicate that SOS is very effective and competitive. [32].

Invasive weed optimization technique was proposed by the author to solve economic dispatch (ED) problems. The ED problem is concerned with minimizing the fuel cost by optimally loading the electrical generators which are committed to supply a given demand. It has been tested on four numerical examples and the results are promising solution. The invasive weed algorithm, a meta-heuristic technique is inspired by the proliferation of weeds. The invasive weed optimization algorithm has been applied to 3 different kinds of ED problems which involve prohibited operating zones (POZ), transmission line losses and valve point loading effects[33].

The authors in their work propose a technique called invasive weed optimization (IWO) for solving Unit Commitment and generation cost problem. The existing technique distributes the load demand among all the generating units. The method proposed here utilizes the output of UC obtained by using the Lagrangian relaxation (LR) method and calculates the required generation from only the plants that are ON discarding the OFF generator units and thereby giving a faster and more accurate response. Moreover, the results show the comparison between the LR-particle swarm optimization (PSO) and LR-IWO, and prove that the cost of generation for a 4 unit, 8 hour schedule is much less in the case of IWO when compared to PSO[34].

The authors in their work has successfully solved optimization problem that arise in the field of electrical engineering (EE) using variant DE and PSO optimisation technique such as Coordination of Directional Over-Current Relays (DOCR). The DOCR protection scheme consists of two types of settings namely current, referred to as 'Plug Setting' or PS, and 'Time Dial Setting' or TDS, which must be calculated. With the optimization of these settings an efficient coordination of relays can be achieved and the faulty transmission line may be isolated with ease, thereby maintaining a continuity of supply to healthy sections of the power systems. Coordination is an important aspect of the protection system design. It was tested and validated on IEEE 3-bus, 4-bus and 6-bus systems [35].

An Adaptive particle swarm optimization (APSO), mixed with simulated annealing (SA) that will be named APSO-SA was proposed and applied to find optimal location, type and size of flexible AC transmission system devices. Two types of FACTS devices, Thyristor Controlled Series Capacitor (TCSC) and Static VAR Compensator (SVC) are considered. The main objectives of this novel algorithm are increasing the voltage stability index and over load factor, decreasing the cost of investment and total real power losses in the power system. This technique increases the search space, improves performance and accelerates the convergence speed, in comparison with the standard PSO algorithm. This suggested technique was validated on IEEE 14-bus systems. Numerical results revealed that the APSO-SA is fast and has much less computational cost. [36].

3.3 Physics and Chemistry based algorithms: Some algorithms are developed by mimicking certain physical and/or chemical laws, including electrical charges, gravity, river systems, etc.

Water Wave Optimisation was proposed to solve the optimal reactive power dispatch problem. The algorithm was implemented on standard IEEE 30-bus power system which validated the effectiveness of the technique to tackle ORPD problem. The WWO algorithm uses propagation, refraction and breaking phenomenon to find the global optimal solution in search space [37].

The author proposed Tabu search algorithm based on an improved hybrid Harmony Search (HS) method to reduce overall grid losses in power system. IEEE 30-bus power grid is used to validate this assumption. The algorithm is applied to find the best location for the installation of a Unified Power Flow Controller (UPFC) [38].

The authors proposed the use of harmony search algorithm for harmonic optimization in multi-level inverters. The technique was used to obtain optimum switching angles for a wide range of modulation indices. The harmony search algorithm is able to find optimum Switching angles in order to cancel out low-order harmonics, and if it is not possible to completely remove them, they can suggest optimum switching angles so that, low-order harmonics will be reduced as much as possible. The results indicate that, harmony search algorithm has many benefits over GA such as simplicity in the implementation, precision, and speed in global convergence. [39].

The authors in their work proposed the use of Gravitational Search Algorithm (GSA) for optimal allocation and sizing of multi-distributed generation (DG) in distribution system for minimum power loss. This technique was validated on 15-Bus IEEE Distribution System and the results revealed that power loss was reduced. GSA outperformed EP in terms of achieving lower minimal power loss [40].

The authors in their work proposed a new method for optimal multi-objective reconfiguration of distribution system based on the fuzzy sets and Galaxy based Search Algorithm (fuzzy-GbSA). The main objectives of the proposed algorithm have been considered as power loss reduction, voltage profile improvement and increase of the system load balancing. The proposed technique has been investigated using the IEEE 33-bus test system and a real distribution network i.e. Tai-Power 11.4-kV distribution system. The obtained results revealed the superiority of the proposed fuzzy-GbSA method in terms of accuracy compared to the GbSA and other intelligent search algorithms such as Genetic Algorithm (GA) or Particle Swarm Optimization (PSO). Furthermore, the proposed algorithm efficiently converged to the optimum solution compared to the other intelligent counterpart algorithms [41]

The author proposed a water wave optimization (WWO) algorithm to solve the optimal reactive power dispatch (ORPD) problem with the continuous and discrete control variables in power system. The WWO algorithm is utilized to find the optimized values of control variables such as generator voltages, tap positions of tap changing transformers and the amount of reactive compensation devices to achieve minimized value of active power losses. The WWO algorithm is implemented on standard IEEE 30-bus power system that is to verify the effectiveness and feasibility of the WWO algorithm to tackle with the ORPD problem. Compared with other algorithms, the WWO algorithm can find the set of the optimal solutions of control variables. The simulation experiment indicates that the WWO algorithm has better overall performance to reduce the real power losses[42].

The author in his work proposed a new optimization technique known as gravitational search algorithm (GSA) and adapted it with pattern search algorithm (PS) to solving the dynamic economic dispatch considering valve point loading effects, ramp rates of generating units and power losses. The proposed hybrid method named communicated GSA–PS

allows balancing between exploitation and exploration capability, which makes agents to react more by changing experiences with local search mechanism. The proposed approach has been examined and applied to three practical power systems, 40 generating units to solving the static economic dispatch, 5 generating units, and 10 generating units considering ramp rates limits, valve point effect, and transmission power losses. From the different case studies, it is observed that the results compared with the other recent techniques demonstrate the particularity of the proposed approach and show clearly its effectiveness to solve Practical dynamic ED problem [43]

Water Wave Optimization Algorithm (WWOA) was presented by the author for solving economic dispatch problems including practical generator constraints. WWOA is inspired by the shallow water wave theory. The efficiency of the WWO Algorithm for solving economic dispatch problems is validated by implementing it on three test systems having three, six and fifteen generating units with non-linear characteristics of the generator such as ramp-rate limits, prohibited operating zones including the system transmission losses. The result of the proposed technique was compared with existing results obtained by GA and PSO solution techniques. The test results reveal the capability of the proposed algorithm as an effective tool for solving various economic dispatch problems in a power system[44].

3.4 Other nature inspired algorithms: Some algorithms are not bio – inspired or Physics/Chemistry – based; it is sometimes difficult to put them in above three categories, because these algorithms are developed by using various characteristics from different sources, such as social, emotional etc.

A new approach based on a constrained pattern search algorithm as proposed to solve well-known power system economic load dispatch problem (ELD) with valve-point effect. The proposed PS technique has been applied to various test systems to validate its effectiveness. Furthermore, convergence characteristics and

robustness of the proposed method has been assessed and investigated through comparison with results reported in literature. The outcome is very encouraging and proves that pattern search (PS) is very applicable for solving power system economic load dispatch problem. [45].

A distributed pattern search algorithm (DPSA) for non-convex economic dispatch in a smart grid is established by the author. The accuracy and effectiveness of the proposed algorithms is verified by numerical simulations, which also show that the DPSA algorithm can improve performance by actively choosing communication topology and integrating other global search methods. When compare with other traditional methods, the DPSA algorithm has comparable performance to these methods [46].

The author proposed a novel algorithm, which is based on a modified Sine-Cosine technique for solving the optimal power flow (OPF) problem. The modified Sine-Cosine algorithm (MSCA) aims at reducing the computational time with a sufficient improvement in finding the optimal solution and feasibility. Levy flights are added to the original Sine-Cosine algorithm to enhance the ability to focus on optimal and avoid local optima. The MSCA presents a simple and robust solution for the OPF problem under different objective functions. The MSCA is validated with solving the OPF problem for a number of benchmark test systems, namely the IEEE-30 bus and IEEE 118-bus systems. The proposed MSCA is compared with other optimization methods to illustrate the effectiveness and potential of the SCA and MSCA algorithms[47].

The authors in their work introduces a new powerful evolutionary algorithm called backtracking search algorithm (BSA) for solving load frequency control (LFC) problem in power system. Initially, two area non-reheat thermal power plants are considered and gains of PI/PID controllers are optimized using BSA. This paper compares BSA's effectiveness in solving LFC problem with the performances of other optimization techniques reported in the literature (PSO& GA, BFOA-PSO). Nonlinearities of power system such as re-heater, governor dead band, boiler dynamics and generation rate constraint are included in the system modelling to identify the system stability and its performance is compared with craziness based PSO technique. Additionally, two more test systems namely three-area and four-area hydro-thermal plant with nonlinearity are considered to demonstrate the efficiency of proposed algorithm. The comparative analysis of the performances indicates that the proposed controller gives better results than other techniques available in the literature. Sensitivity analysis showed robustness of proposed controller under loading and parameter uncertainty[48].

Tabu search algorithm was proposed to help the control center split the power system into different islands; the corresponding problem is called the power system islanding problem. The critical components of the tabu search algorithm are the procedure of generating good initial solutions and the effective neighborhood operations. The algorithm was used to design a novel two-stage approach to construct the initial solution and then improve the initial solution by a neighbourhood operation based on the movement of boundary nodes. The effectiveness and efficiency of this algorithm have been proven by the numerical experiments on 15 instances of various numbers of nodes. It is able to achieve high quality splitting strategies for the power systems with up to 3120 nodes within 0.7 s. The comparisons with some existing islanding methods based on the IEEE 39-bus system and the IEEE 118-bus system prove the validity and accuracy of our method [49].

Tabu search algorithm was proposed to solve the optimal load distribution strategy problem for the cooling system constituted by multiple chiller water units. Two chiller water units connected in parallel and working together using the tabu algorithm was observed closely. When compared with the conventional method, the results indicated that the tabu search algorithm has much less power consumption and is very suitable for application in air condition system operation [50].

IV. CONCLUSION

An overview on the application of natured inspired optimization techniques in a restructured power system has been discussed in detail. The traditional optimisation techniques have some shortcomings. The classical optimization technique is constrained, particularly when the size of the power system increases with its non-convexity problems. In addition, when technical criteria techniques for solving power system problems are considered, despite that there is an improvement in the power system performance; it is not possible to evaluate the degree of optimality of the solution provided by these methods. Today, there is no venture in power business without the hope of return and there is no energy supplied if it is gainful. Natured inspired optimisation techniques have gained the interest of many researchers because of the simplicity in their implementation and their capability of handling highly non-linear systems and finding optimal solutions in a reasonable amount of computational time.

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