IMPLEMENTATION OF VARIOUS OPTIMIZATION TECHNIQUES TO SYNCHRONOUS GENERATOR - A SURVEY

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ABSTRACT

This paper portrays different optimization technique for analyzing the synchronous generator. The intention of this paper is to identify the best optimization for the Synchronous Generator to get the accurate modeling and parameter estimation. The most common goals are minimizing cost, maximizing throughput, and/or efficiency.

Keywords: Ant Colony Optimization (ACO), Artificial Bee Colony Optimization (ABCO), Finite Element method (FEM), Genetic Algorithm, Stand Still Frequency Response (SSFR), Particle Swarm Optimization (PSO).

I. INTRODUCTION

Optimization is a mathematical chastisement that affairs the discovery of minima and maxima of functions, subject to so-called constraints. Today, optimization embraces a wide variety of techniques from Operations Research, artificial intelligence and computer science, and is used to convalesce business processes in practically all industries. Process optimization is the chastisement of adjusting a process so as to optimize some stipulated set of parameters without violating some constraint. The most common goals are minimizing cost, maximizing throughput, and/or efficiency. This is one of the major quantitative tools in industrial decision-making. When optimizing a process, the goal is to maximize one or more of the process specifications, while keeping all others within their constraints. Optimization is influencing the esthetics as well as the structure of products, which can be seen in the design of robotics and aerospace components, as well as more typical examples such as cars. The use of optimization can help to ripen the design process with the concept of a product and inspire entirely new products, by showing what is and isn't possible, and the best shapes
or other features. Using modeling and rendering tools, which come originally from the world of industrial design, can evolve product design. Simulation and optimization tools are becoming extremely sophisticated. Some of Altair’s partners’ products can show such fine detail that they let design engineers look at crack propagation in composite materials, Dagg said.

In power system operation the optimization is used for solving the problem of uncertainty analysis in power system, optimal reconfiguration of electrical distribution network, optimal load scheduling, reactive power optimization, steady state security regions, optimal power flow, unit commitment, multiarea system economic dispatch, security constrained economic dispatch, classic economic dispatch, sensitivity calculation, power flow analysis. In the last two decades several contemporary heuristic tools have been evolved that facilitates solving optimization problems that were hitherto difficult or intolerable to solve, these tools include traditional and modern optimization methods. Which have been developed to solve these power system operation problems and are classified into three groups (1) Conventional optimization methods including (Unconstrained optimization approaches, nonlinear programming (NLP), Linear programming (LP), Quadratic programming (QP), Generalized reduced gradient method, Newton method, Network flow programming (NFP), Mixed-integer programming (MIP), Interior point (IP) methods). (2) Intelligence search methods such as Neural network (NN), Evolutionary algorithms (EAs), Tabu search (TS), Particle swarm optimization (PSO) (3) Nonquantity approaches to address uncertainties in objectives and constraints including Probabilistic optimization, Fuzzy set applications, Analytic hierarchical process (AHP). Latterly, genetic algorithms (GA) and particle swarm optimization (PSO) technique have interested substantial attention among various modern heuristic optimization techniques. Techniques such as PSO and Genetic Algorithms are inspired by nature, and have proved that they to be effective solutions to optimization problems.

The need of optimization is essential in synchronous generator for accurate modeling and parameter estimation. Analytical models for synchronous machines are based on Park’s transformation which involves superposition of effects in the direct and quadrature axes and these Park’s equation were extended by Crary and Concordia which include any symmetrical stationary network connected to the armature [1]. The optimization criteria for synchronous generator may be technical, economical or functional. The technical criteria refer to technical operating performance. The economic criteria refer to the design of a generator such that its cost is lowest, during its whole running period. The functional criteria refer to generator designs that ensure a safe functioning during transient processes and short time emergency operations. By finding the optimum values, for the structural dimensions and optimal parameter values in design of synchronous generator can attain total minimum cost which dependent on the current layer of the generator [2].

A power outage (also power cut, blackout, or power failure) is a short- or long-term loss of the electric power to an area. There are many causes of power failures in an electricity network includes faults at power stations, damage to electric transmission lines, substations or other parts of the distribution system, a short circuit, or the overloading of electricity mains. Power failures are particularly critical at sites institutions such as hospitals, sewage treatment plants, mines, and the like will usually have backup power sources such as standby generators, which will automatically start up when electrical power is lost. Other critical systems, such as telecommunications, are also required to have emergency power. Telephone exchange rooms usually have arrays of lead-acid batteries for backup and also a socket for connecting a generator during prolonged periods of outage.

Power quality determines the fitness of electrical power to consumer devices. Synchronization of the voltage frequency and phase allows electrical systems to function in their intended manner without significant loss of performance or life. The term is used to describe electric power that drives an electrical load and the load’s ability to function properly. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all. There are many ways in which electric power can be of poor quality and many more causes of such poor quality power.
II. DIFFERENT OPTIMIZATION ALGORITHMS

A) Ant Colony Optimization

By applying Ant colony optimization (ACO) for parameter estimation of synchronous generator stretches the virtues of rapidness and global optimization depend on transient behavior of the machine and a step added to the field system [3]. For penetrating the optimal point of maximum load ability point at a load bus the Ant Colony Optimization (ACO) technique are used. By using this technique the optimal points are identified in the off-line mode, it can abet the power system operators to execute pilot study prior to envisioned load increment in their transmission system. The ACO has advantage over the evolutionary programming (EP) and automatic voltage stability analysis (AVSA) in terms of its accuracy and least computation time and this technique able to reduce computation burden in an optimization process [4]. ACO is used for hawked problem of parameter identification in partial discharge PD analysis is secondhand for modeling of the phenomenon of partial discharges in dielectrics [5]. For solving multi-dimensional continuous space optimization problems an improved ant colony algorithm are used. An improved ant colony algorithm is applied for aggregation of generator dynamic parameters from aggregation of generator electromagnetic circuit and excitation system spectacles viable and available results [6]. OPF is a non-linear and a hefty combinatorial problem, for these ACO has been successfully applied. This technique has been developed to be expended for maintenance and repairing planning with 48 to 24 hours expectancy. The main advantage of this method is for analyzing large set of consequences in OPF, ACO exhibits low execution time [7].

B) ARTIFICIAL BEE COLONY ALGORITHM

Artificial Bee Colony (ABC) is one of the most recent computational intellects to solve the optimal power flow (OPF) problems and it is effective than other swarm intelligence methods. Bees Algorithm can converge for superior solution marginally faster than the rest methods [8]. The social benefit and the distance of maximum loading can be reduced by an interior point method to solve multi-objective function for optimal power flow [9]. Economic Dispatch (ED) problem with generator constraints can be solved by the implementation of Bee Colony Optimization (BCO). BCO algorithm demonstrates superior characters such as high-quality solution, stable convergence characteristic and good reckoning efficiency. The method of BCO for solving the constrains of ED problems attain higher quality solution, efficient and faster computational time than the conformist methods [10]. The cost minimization and congestion management will be maintained by applying BCO. Significantly system security is preserved such that the current flow in the power system network and controlling the transmission constraints carries cost minimization. By optimizing the generated power in the system the fuel cost will be minimized [9]. The dynamic economic dispatch problem is elucidated by artificial bee colony (ABC) algorithm. Comparing with hybrid harmony search (HHS) and adaptive particle swarm both the above method attains “less” operating fuel costs than that of the ABC algorithm [11]. In the radial distribution systems by placing Artificial Bee Colony algorithm (ABC) instead of Distributed Generators (DG), which reduces the real power loss, green house effects, and to improve supply quality and voltage profile and also reduce line loss and environment impact. It will achieve less CPU time-consumption and high solution quality. This algorithm shows its ascendancy and probable for solving complicated power system [12]. The ABC algorithm solves the optimal dynamic dispatch problem in power system. Which cogitated the generator nonlinear characteristics, such as valve-point effects and the transmission network losses? Furthermore, the mechanism and some parameters of this algorithm are analyzed and their numerical results show that for certain type of fuel cost functions; the algorithm can provide accurate dispatch solutions within reasonable time [13]. For rescheduling the generators the Artificial Bee colony Optimization is used which maintain the congestion management based on choosing the
generator sensitivity factor (GSF). Based on penalty function methodology the constraints are handled and effects on other critical lines due to rescheduling have been mentioned in the paper [14].

C) FINITE-ELEMENT METHOD

The finite-element method is accomplished to salient pole synchronous generator to extent the unbalanced magnetic forces due to eccentric motion of the rotor shaft under no-load and loaded condition. The influences of the stator winding parallel paths and the rotor damper winding on mitigation of unbalanced magnetic pull can be analyzed by FEM [15]. FEM are used for dissecting the harmonic distortion factor in output voltage of synchronous generator by calculating the stator coil flux linkages and contemplation is given to rotor movement through two-dimensional finite-element modeling. For satisfying the requirement for the maximum acceptable waveform distortion factor, this technique may be useful for prime pole shape design [16].

![Fig 1 Model analysis for FEM](Image)

By modernization of hysteresis cycle the modeling in electrical machine can be done for iron loss improvement. An accurate measuring of magnetic flux density waveform is implemented to electrical machine after the FEM calculation at various points [17]. 2D FEA are used for concurrent reduction of iron losses and magnetic noise of a wound-field synchronous machine by cogitating various stator tooth lengths and rotor pole air gap surface radii and their impact gives adequate change during design. To compute iron losses as well as details of the weak coupling between the magnetic and structural finite element models are used which compute the magnetic noise. In addition to that magnetic forces can be calculated, the couple iron loss and acoustic optimization can be achieved by FEA, the adequate torque decrease are determined for achieve other benefits. Adequate choices throughout the design, for driving the tool are achieved by FEM method [18]. The static and dynamic rotor eccentricities of a synchronous generator at no load are studied by using 3-D FEM. This method reduces simulation time because it does not require enmeshing for fault case simulations [19]. The brushless self-excited single-phase synchronous generator has been studied by using direct finite element method and their flux distribution and the characteristics of generator have been clearly shown. The output voltage is kept near constant for a wide range of load without AVR [20].
D) GENETIC ALGORITHM

The synchronous-machine equivalent circuits parameters from standstill frequency response data can be obtained by using a hybrid genetic algorithm. The global minimum value can be founded by genetic algorithm within a search interval of the fitness function. Which are used for matching the equivalent circuit and the measured machine transfer functions. The transfer functions of a turbine generator can be determined by Finite-element modeling [21]. During a change in reference voltage level the optimization problem of minimizing the model’s forecast error can be solved by genetic algorithm. For hysteretic brushless exciter model parameter can be identified by GA method. The observed and simulated waveforms of the synchronous generator error can be minimized based on the difference between time-domain systems. It not only provides means for characterizing complex models, but they should inspire the derivation and utilization of more detailed and state-of-the-art models. This method proposes great flexibility to the predictor [22]. The genetic algorithm can design the optimal fuzzy logic controller for the generating unit. The generator terminal voltage and the rotor angle speed deviation are given to the inputs as the results both the voltage profile and the dynamic stability of the generating unit are augmented by designing [23]. The multi-parameter optimization problems are solved by plagiaristic of population diversity based genetic algorithm (PDGA), which is used to design an optimal fuzzy excitation controller for synchronous generator. It is self-optimizing method for designing a FLC by the help of GA. This method reduces the number of optimized controller parameters, and implies that the method keeps great potential for broader application [24].

E) HOOK-JEEVES OPTIMIZATION & SSFR TEST

The dynamic parameters of the machine are acquired by using Standstill Frequency Response (SSFR) test. Hook-Jeeves optimization method is mostly used for parameter estimation purpose. The SSFR test involve some merits, are require very little power and easy implementation, ready accessibility of powerful computer tools has alleviated the data logging and analysis procedures, and it can simultaneously provide the equivalent circuits for both direct and quadrature axes. It is a time saving method, that estimated model can be used for studying stability and low frequency oscillations ad design and tuning power system stabilizers of the generator [25]. The SSFR test data are used to schoolwork the effect of noise on the expected parameters. The estimation algorithm should not be affected by the noise and the estimation technique should require a minimum prior knowledge, these two issues can be effectively dealt by using maximum likelihood (ML) estimation [26]. Simulation data for generators from SSFR test can be strong-minded by using of maximum likelihood technique. The method used for data determination is similarly used for simulation models and used to calculate the stability and dynamic performance of the machine [27]. The Standstill Frequency Response Test (SSFR) establishes the direct and quadrature axis operational impedances for salient pole synchronous machine. It is then applied with the rotor at standstill in a given arbitrary position, thus avoiding the difficulties in rotor mechanical alignment and rendering it suitable for large salient pole synchronous machines. Applying a variable-frequency, reduced-voltage source and measuring the magnitude and phase of the resulting current for each frequency at a specified range can obtain the machine impedance. The main advantage of this technique is that the machine can be tested with the rotor at standstill, stopped at an arbitrary position [28]. The empathy of synchronous machine models can be achieved by direct maximum-likelihood (ML) estimation process based on the standstill frequency response (SSFR) test data. The results show that by encompassing both the open and short-circuit the SSFR physiognomies of the two generators can be precisely represented by the established high order synchronous models up to 1 kHz [29].
PARTICLE SWARM OPTIMIZATION

PSO is an intellectual computational method based on a stochastic search. For solving the complicated engineering problems PSO consider to be versatile and efficient tool. Synchronous machine model output to be expended as the objective function in modified version of PSO, thus sanctioning a new more efficient method for parameter identification [30]. For identification of non-linear system Least Mean Square Algorithm (LMS) and GA Algorithm hold some demerits. In LMS the weights rattle around and do not converge to optimal solution. In GA contributes slower convergence rate. PSO technique identifies the nonlinear system and overcome the problem presents in LMS and GA [31]. PSO is mainly expended for optimization problem. For transforming the identification problem into optimization PSO are used to identify the unknown parameter in this model and these technique is faster than real time simulation [32].

III. CONCLUSION

The surveys of various optimization techniques for synchronous generator are analyzed and studied. From the above study it is observed that the PSO technique is best and well suited for parameter optimization. The uniqueness of this technique is that it can extract accurate value. The main advantage of this technique is the parameter extraction can be reformulated.

IV. REFERENCE

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