A Novel Approach for Optimal Power Flow in Power Networks Including FACTS Devices Using PSO

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***Abstract*—In this paper, three particle swarm optimization (PSO) algorithms are compared with one new PSO algorithm for power flow control needs of flexible AC transmission system (FACTS) in studying the optimal power flow (OPF) problem. Two types of FACTS devices namely thyristor controlled series compensators (TCSC) and static synchronous compensator (STATCOM) are considered. The proposed method makes use of the PSO, known for its global searching capacities, to allocate the optimal control settings while Newton-Raphson algorithm minimizes the mismatch of the power flow equations. The obtained results by the GPAC, LPAC, CA and NCA on the IEEE 30-bus are compared, demonstrating the excellent performance of the proposed PSO algorithm.**

I. INTRODUCTION

Electric power grids are considered the most complex man-made systems due to their wide geographical coverage, various transactions among different utilities, and diversity in individual electric power companies' layouts, size, and equipment used. Nowadays making the power networks operate in a more flexible, secure and economic way leads to using flexible AC transmission system (FACTS) devices in many power networks in the world. The concept of FACTS was first defined by Hingorani, N.G [1] in 1998. Also OPF is an important analyse for managing the system in optimal working point. The goal of OPF is to find the optimal settings of a given power system network that optimize a certain objective function while satisfying its power flow equations, system security and equipments operating limits. Different control variables, some of which are generators' real power outputs and voltages, transformer tap changing settings, phase shifters, switched capacitors, and control variable of FACTS devices, are manipulated to achieve an optimal network setting based on the problem formulation. The most commonly used objective for OPF formulation is the minimization of the overall fuel cost function. However, other traditional objectives are minimization of the active power loss, bus voltage deviation and emission of the generating units. Various traditional optimization techniques were developed to solve the OPF problem [2,3] but the most popular ones are linear programming and sequential quadratic programming. Each of these techniques have some advantages and disadvantages but in general they are local optimizers in nature and might converge to local solutions instead of global ones if the initial guess happens to be in the neighbourhood of a local solution. This happens as a result of using Kuhh Tucker conditions as termination criteria to detect stationary points. This practice is commonly used in most commercial nonlinear optimization programs [4].

In this paper, an effort of developing more effective PSO algorithm by reflecting recent advances in swarm intelligence and, in addition, by introducing new concepts is proceeded. The main idea behind this method is changing the particles' locations based on the swarm forces [5]. In [6] an operator of passive congregation in the global variant PSO, the general passive congregation (GPAC-PSO), is introduced. The application of this operator in the local neighbourhood variant PSO [7] by enhancing it with the constriction factor approach [8,9] leads to LPAC-PSO in [10]. Another completely different type of PSO algorithm is introduced in [10], which is based on the coordinated aggregation (CA) observed in swarms. At each iterative cycle of CA, each particle updates its velocity, taking in to account the differences between its position and the position of better achieving particles. In this paper a new method, namely new coordinated aggregation (NCA) is proposed. In the NCA method the position of each particle in very iteration is updated, taking to account the better achieving and worse achieving particles. The best particle of the swarm in NCA is acted like "crazy particle" in [11].

In this paper, NCA method is compared with other introduced PSO based method to demonstrating its excellent performance. IEEE 30-bus system is selected as the test network, which is incorporating FACTS devices, TCSC and STATCOM, in different cases.

II. OPF FORMULATION

The OPF goal is to optimize a certain objective subject to several equality and inequality constraints. The problem can be mathematically modeled as follows:

$$Min F(x,u) \tag{1}$$

Subject to:

$$g(x,u)=0 \tag{2}$$

$$h_{\min} \le h(x,u) \le h_{\max} \tag{3}$$