An Application of Multi-Verse Optimizer for Optimal Reactive Power Dispatch Problem

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***Abstract*—This paper proposes a new algorithm namely Multi-Verse Optimizer (MVO) in solving the Optimal Reactive Power Dispatch (ORPD) problem. It is inspired from the three main concepts in cosmology viz. white hole, black hole and wormhole. These concepts are developed mathematically to perform exploration, exploitation and local search respectively. This algorithm is applied to obtain the best combination of control variables such as generator voltages, tap changing transformer's ratios, reactive compensation devices as well as real power generation. In this paper, to show the effectiveness of MVO into ORPD problem, IEEE-30 bus system with 25 control variables is utilized and compared with recent algorithms available in literature. The result of this study shows that MVO is able to achieve less power loss than those determined by other techniques.**

Keywords-Loss minimization, Multi-Verse Optimizer, Nature Inspired Algorithms, Optimal Reactive Power Dispatch

I. INTRODUCTION

Optimal reactive power dispatch (ORPD) is one of the nonlinear and non-convex problems in power system planning and operation. Control variables or parameters for ORPD normally have close relationship with reactive power flow such as voltage magnitudes of generator buses, transformer tap ratios and reactive compensation elements [1]. In literature, there are several objective functions that have been addressed and assessed to achieve the successful of ORPD such as loss, voltage deviation and voltage stability index minimizations [2]. Nevertheless, for this paper, only loss minimization is used for objective function to overcome the ORPD problems. In order to achieve this objective, the stated control variables need to be controlled and set accordingly.

It is a nonlinear problems and difficult task since all the controlled variables need to be set simultaneously to achieve the minimum loss. That is why there are massive researches have been done to overcome this problem such as by using classical techniques including Newton techniques [3], sequential quadratic programming [4] and non-linear solver with penalty based [5].

Recently, many nature inspired algorithms have been proposed to solve ORPD such as grey wolf optimizer (GWO) [6], artificial bee colony (ABC) [1], harmony search algorithm (HSA) [2], particle swarm optimization (PSO) [7], honey bee mating optimization (HBMO) [8], gravitational search algorithm (GSA) [9] and many more to come.

This paper proposes the recent algorithm based on the universe cosmology concepts to solve ORPD problem. This algorithm has been proposed by [10]. The organization of this paper is as follows: Section 2 presents the ORPD formulation while brief description of MVO is discussed in Section 3. It is followed by the implementation of MVO into solving ORPD problem in Section 4. Section 5 presents the results and discussion and finally the conclusion is stated in Section 6.

II. OPTIMAL REACTIVE POWER DISPATCH

ORPD problem is one of the most complex problems in power engineering system which can be described as the minimization of function *f*(x, u) subject to the following expressions:

$$g(x,u)=0 \qquad h(x,u)\le 0 \tag{1}$$

where $g(x,u)$ and $h(x,u)$ are the equality and inequality constraints respectively, x is the dependent variables and u is the control variables. In this paper, the objective function of $f(x, u)$ is to minimize the transmission loss system.

The equality constraint equation is the power balanced of load flows which are expressed as follow [2]:

$$\begin{aligned} P_{Gi}-P_{Di} &= V_i\sum V_j\left(G_{ij}\cos{}^{-}_{ij}+B_{ij}\sin{}^{-}_{ij}\right)\\ Q_{Gi}-Q_{Di} &= V_i\sum V_j\left(G_{ij}\cos{}^{-}_{ij}-B_{ij}\sin{}^{-}_{ij}\right)\end{aligned} \tag{2}$$

The inequality constraints are represented in terms of operating constraints such as generators' constraints (upper and lower bound), transformer tap setting as well as reactive elements' upper and lower limits, expressed as follow [6]:

$$P_{Gi}^{\min}\le P_{Gi}\le P_{Gi}^{\max} \qquad i=1,\dots,N_G \tag{3}$$

$$V_{Gi}^{\min}\le V_{Gi}\le V_{Gi}^{\max} \qquad i=1,\dots,N_G \tag{4}$$

$$T_i^{\min}\le T_i\le T_i^{\max} \qquad i=1,\dots,N_T \tag{5}$$

$$Q_{Ci}^{\min}\le V_{Ci}\le V_{Ci}^{\max} \qquad i=1,\dots,N_C \tag{6}$$

where N_G, N_T and N_C are number of generators, number of transformers and number of shunt compensators respectively. It is worth to highlight that in this paper that the MATPOWER software package [11] is utilized to obtain total transmission loss by running the load flow program in order to obtain the precise result.