IMPLEMENTING MODIFIED PARTICLE SWARM OPTIMIZATION METHOD TO SOLVE ECONOMIC LOAD DISPATCH PROBLEM

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To my beloved mother and father

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ABSTRACT

Economic Load Dispatch (ELD) is one of the important optimization tasks which provide an economic condition for power systems. In this work, Modified Particle Swarm Optimization (PSO) as an efficient and reliable evolutionary based approach has been proposed to solve the constraint economic load dispatch problem. The proposed method is able to determine, output power generation for all of the power generation units, so that the total, constraint cost function is minimized. In project report, a piecewise quadratic function is used to represent the fuel cost of each generation units, and the B-coefficient method is used to model transmission losses. The feasibility of the proposed Modified PSO is demonstrated for 4 power system test cases, consisting 3,6,15, and 40 generation units. The obtained Modified PSO results are compared with Standard PSO (SPSO), Genetic Algorithm (GA) and Quadratic Programming (QP) base approaches. These results reveal that the proposed method is capable to get higher quality solution including mathematical simplicity, fast convergence, and robustness to solve hard economic load dispatch problem.

ABSTRAK

Penghantaran Beban Ekonomik (Economic Load Dispatch (ELD)) adalah salah satu tugasan pengoptimuman penting yang menyediakan persekitaran ekonomik bagi system kuasa. Didalam tugasan ini, *Modified Particle Swarm Optimization (PSO)* telah diusulkan untuk menyelesaikan masalah penghantaran beban ekonomik terhad secara evolusi efisien dan tepat. kaedah yang diusulkan dapat menentukan penghasilan kuasa output untuk semua unit penghasilan kuasa supaya jumlah fungsi kos terhad adalah minimal. didalam laporan projek, sebuah fungsi kuadratik cebisan digunakan untuk mewakili kos minyak bagi setiap unit penghasilan kuasa dan kaedah B-Coefficient digunakan to memodelkan lesapan transmisi. kebolehan kaedah PSO terubah yang dicadangkan telah didemonstrasikan untuk empat kes ujian sistem kuasa yang mengandungi 3,6,15, dan 40 unit penghasilan kuasa. keputusan PSO terubah yang diporolehi adalah dibandingkan dengan PSO biasa (SPSO), Algoritma Genetik (GA) dan Pragram Kuadratik (QP) asas. Keputusan yang diporolehi menunjukan kaedah yang dicadangkan berupaya untuk mendapatkan kualiti penyelesaian yang lebih tinggi serta kaedah metematik yang medah, penumpuan yang lebih cepat dan tegar untuk menyelesaikan masalah penghantaran beban ekonomik yang susah.

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LIST OF ABBREVIATIONS

ELD	-	Economic Load Dispatch
QP	-	Quadratic Programming
GA	-	Genetic Algorithm
PSO	-	Particle Swarm Optimization
SPSO	-	Standard Particle Swarm Optimization
MPSO	-	Modified Particle Swarm Optimization

LIST OF SYMBOLS

$V_i(t)$	-	Current velocity of particles
$V_i(t+1)$	-	Updated velocity of particles
$X_i(t)$	-	Current position
$X_i(t+1)$	-	Updated Position
W	-	Inertia Weight
X_{pbest}	-	Personal Best
X_{gbest}	-	Global Best
C_i	-	Cost Function
$\alpha_i, \beta_i, \gamma_i$	-	Cost Function coefficients
P_i	-	Output Power Generation
B_{ij}	-	Transmission Losses Coefficient Matrix
L	-	Lagrangian Multiplier
λ	-	Penalty Factor
r_1, r_2	-	Scaling Factor
c_1, c_2	-	Acceleration Coefficients

CHAPTER 1

INTRODUCTION

1.1 Introduction

The economic load dispatch problem, as one of the important issues of power systems has been widely investigated in recent decades. Many researchers have proposed useful methods for minimizing the total costs of the electrical power dispatch. Some of these methods have computational restrictions that sometimes cannot fully optimize some of the optimization problems. In addition to the existing mathematical methods which are sometimes associated with complex mathematical calculations, simple and high performance approaches have also been proposed by those researchers, in solving this problem.

In real world power systems, electrical power generation units are not located at the same distance from the center of the load. Apart from that, electrical power generation costs for each of these units are also different in terms of fuel, maintenance, labor etc. Due to this variety of power generation costs, the most important problem is to prepare a schedule which is the most efficient and economical that can be followed by a power system. In recent years, many optimization methods on the problem of economic load dispatch, as a constraint

optimization problem, have been studied where all researches try to find which method is more efficient and faster in execution and also easier to implement.

1.2 Introduction to the Classical Solution Methods on Economic Load Dispatch Problem

Newton's base algorithm method, as one of the primary and useful approach, has been used widely to solve economic load dispatch problem for a power system. However, this method is useful only for optimizing continuous and derivable functions, and is not applicable to those functions which are not continuous. The complexity in mathematical equations in this method, especially when the number of variables is high, has led researchers to other methods of solving the optimization problem. They try to design algorithms that can run in terms of simplicity and can be more practical. Besides that, the Newton's base algorithm method as an iteration base method can only be used with a suitable initial condition. Only then can the convergence of this algorithm be guaranteed. Otherwise it may converge to non optimum point.

1.3 Introduction to Particle Swarm Optimization Method

Particle Swarm optimization method has been used many times for optimization tasks including solving economic load dispatch for a power system. This stochastic and iteration base method, by following a defined algorithm tries to lead particles and finally the swarm to obtain an optimum region and after that to obtain best point, in the search space. A completely randomized particles is selected where their velocity and location in the next iterations will be updated, based on the

existing formulas. After a limited number of iterations, the particles will obtain the best solution for the problem and all particles will converge to the best point. This method does not need any information about the derivative of function and has a higher flexibility to solve any constraint optimization problem and thus can be used to optimize a wide range of functions with various constraints. This method is compared considered superior to other classical methods, since it does not need to solve complex mathematical formulas in finding the best solution for the problem. Various modifications have been applied to increase the efficiency and performance of this method in recent years. Some of these modification methods will be briefly discussed in the next part of this report and it will be explained in more detail in the next chapter.

1.4 Introduction to Improvement of Particle Swarm Optimization Algorithm

Many researchers have concentrated on deriving a modified equation to update the velocity and position for each of the particles in the swarm. The aim of this modification is to obtain a higher performance algorithm through the use of mathematical formulas and principles of optimization. In general, the methods that focus on movement and velocity of particles, including Genetic base Algorithm methods and that based on Artificial Intelligence have also been used for this purpose. The important thing that the researcher must consider is making the stability, convergence and the speed of convergence of particles toward some certain places.

1.5 Problem Background

As mentioned before, the problem areas on the economic load dispatch problem for a power system can be solved by various methods. Each of these methods tries to obtain a more desirable result. The particle swarm optimization method has also been applied widely to solve this problem in the last few years. However the existence of some shortcoming in this algorithm, has led researchers to define and design some Hybrid and modification on this algorithm to improve its efficiency and performance.

1.6 Objectives of Project

1. To analyze and solve economic load dispatch problem by classical method.

2. To implement standard PSO and modify the algorithm of standard PSO by defining a new scaling function.

3. To solve ELD problem for four IEEE test cases by classical method, standard PSO and modified PSO and then compare the results obtained by these method using Genetic Algorithm method.

1.7 Introduction to the Proposed Modification Method

In the particle swarm optimization method, based on the constraints of the optimization problem, the particles initialize in the bounded area of search space. Those particles that leave the search space are returned to this defined region by these algorithms. In the next chapter this algorithm will be described in detail.

Another important factor in the convergence algorithm is using the formula to calculate the position and velocity of particles. This work tries to introduce a new function that can increase the convergence, efficiency and also speed of the convergence. The superiority of this method has been shown by showing the performance of some different functions.

1.8 The Outline of project report

In previous parts, the summary, goals and procedures have been explained. In this part, a more general view of this thesis will be shown. The remainder of the thesis is organized into five main chapters. Chapter Two discusses the literature review on the modified methods of the particle swarm algorithm that implementing various methods including Genetic Algorithm, Neural Network, Quadratic Programming and etc to solve the economic load dispatch problem.

It will be followed by introducing the particle swarm optimization method, its structure and properties. The classical method to solve the economic load dispatch problem is discussed in detail in Chapter Three. Besides that, the modification approach to improve the performance of the particle swarm optimization algorithm and evaluation rate of convergence, quality of convergence etc, will also be discussed.

The economic load dispatch problem will be solved for various IEEE power system cases by means of new modified PSO in Chapter Four. The results obtained will be compared with the results of the standard PSO, Genetic Algorithm and classical method. Finally, at the end of this thesis we will discuss the result give the conclusion of the new proposed PSO method which will be in Chapter Five.

1.9 Summary

In this chapter, the aim of this project and some theory is explained briefly. Then, the history and background are reviewed. In addition, the problem statements and objectives also mentioned. In the last section of this chapter, the outline of the overall research is explained.

REFERENCES

[1] Frans van den bergh, "*An analysis of Particle Swarm Optimization*," PHD Thesis, university of Pretoria-Pretoria November 2001.

[2] Nadia Nedjah, Luiza de Macedo Mourelle, "*Swarm Intelligent System*," Spring Berlin Heidelberg New York, 2006.

[3] Andries P.engelbrecht, "*Computational Intelligence*," John Wiley & sons, New York, 1984.

[4] Fukuyama, Y.; Ueki, Y, " *An application of artificial neural network to dynamic economic load dispatching*," Neural Networks to Power Systems, 1991., Proceedings of the First International Forum on Applications of 23-26 July 1991 Page(s):261-265 Digital Object Identifier 10.1109/ANN.1991.213466.

[5] Nidul Sinha, Chakrabarthi.R and Chattopadhyay.P.K, "*Evolutionary Programming Techniques for Economic Load Dispatch*," IEEE Transactions on evolutionary computation, Vol. 7, 2003, pp.83-94.

[6] Mekhamer, S.F.; Moustafa, Y.G.; EI-Sherif, N.; Mansour, M.M, "*A modified particle swarm optimizer applied to the solution of the economic dispatch problem*," Electrical, Electronic and Computer Engineering, 2004. ICEEC '04. 2004 International Conference on, 5-7 Sept. 2004 Page(s):725 – 731.

[7] Pancholi, R.K.; Swarup, K.S, "*Particle swarm optimization for security constrained economic dispatch*," Intelligent Sensing and Information Processing, 2004. Proceedings of International Conference on 2004 Page(s):7 - 12 Digital Object Identifier 10.1109/ICISIP.2004.1287615.

[8] Ling, S.H.; Lu, H.H.C.; Chan, K.Y.; Ki, S.K, "*Economic load dispatch: A new hybrid particle swarm optimization approach*," Universities9-12Dec.2007 Page(s):1 – 8 Digital Object Identifier 10.1109/AUPEC.2007.4548052.

[9] Vanaja, B.; Hemamalini, S.; Simon, S.P, "*Artificial Immune based Economic Load Dispatch with valve-point effect*," TENCON 2008 - 2008, TENCON2008. IEEE Region 10Conference 19-21 Nov. 2008 Page(s):1-5.

[10] Hadi Saadat, "*Power System Analysis*," McGraw-hill companies, Inc, 1999.

[11] Zdenek-Dostal , "*Optimal Quadratic Programming Algorithms* ," Springer,1 edition (March 5, 2009).