VIETNAM NATIONAL UNIVERSITY
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DISSERTATION'S INFORMATION

Dissertation's title: **CALCULATION TO DETERMINE THE STRUCTURE AND OPTIMAL OPERATION OF MICROGRID POWER GRID USING INTELLIGENT SEARCH ALGORITHM**

Major: **ELECTRICAL ENGINEERING** Major code: **9520201**

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Summary of new academic and theoretical contributions of the dissertation:

1.1 Method

The dissertation applies intelligent search algorithms to solve problems of determining the structure and optimal operation of microgrids. The dissertation focuses on studying algorithms and then improving algorithms to achieve the goal of finding optimal solutions for the given problems. Therefore, the first contribution of the dissertation is in the method. The thesis has 3 main contributions in terms of method.

1.1.1 Improved SFS algorithm

SFSA is a powerful algorithm in finding optimal solutions, however, because the process of finding optimal solutions must go through many stages, the convergence speed of the algorithm in some cases is not as expected. This affects the ability to find optimal solutions in the fastest time with the best resources.

Therefore, the thesis has conducted research and analysis of the algorithm, from which the algorithm has been improved by constructing an adjustment coefficient in the algorithm. This coefficient is chosen to be in the range [0,1]. This coefficient is included to improve the diffusion stage.

As presented above, the use of which formula in the Gaussian step will strongly affect the convergence speed. Steps with large distances will cause many extreme points to be missed, but small distance steps will cause the population size of the diffuse points to be large, increasing the space and volume of the search. Therefore, the author builds a program to choose the value of h_{dc}, the smaller h_{dc} is, the lower the complexity of the input conditions and variables.

The author has applied this coefficient to perform the search for the optimal solution for 4 problem models. Thanks to the application of this coefficient, the solution is fast and optimal.

1.1.2 Improved SOS algorithm

SOSA is applied to optimization problems to obtain efficient solutions. The processes of exploration, search and parasitism. These processes are effective in finding optimal solutions. However, the exploration and exploitation processes and the exploration and exploitation capabilities of SOSA are not always flexible. In certain cases, the algorithm still encounters local stagnation in the process of searching for local optimal values. Meanwhile, this is the effectiveness of an optimization method.

Like metaheuristic algorithms, SOSA can get stuck in local optima due to their random nature. To improve this, the quadratic interpolation strategy (SQI) method has been integrated into it to enhance the search function of SOSA.

The SQI algorithm generates new solution vectors on a point of the minimum quadratic curve passing through three randomly selected solution vectors (3-point SQI). Applying these characteristics of SQI to SOSA improves the convergence speed and search ability of the algorithm. In this thesis, we will use 3-point SQI as a tool to determine the d-th dimension of a newly generated individual after the parasitic phase.

1.2 Research problem

1.2.1 Correlation coefficient

The thesis studies the problem of optimizing emission costs and fuel costs. In the process of researching the thesis, it is necessary to solve the relationship between the emission cost function and the fuel cost function. How to choose to ensure the proposed objectives. The thesis has focused on analyzing to determine the correlation coefficient between these costs to achieve the conformity between the proposed objectives.

The correlation coefficient is the coefficient of connection between the two values of emission cost and fuel cost. For a single generator, the tendency of high fuel cost is that the emission cost will be high and proportional to the generating capacity of the device. Therefore, the emission cost of fuel for a generator will be high. However, for the microgrid system, it is a combination of many types of energy sources. All generators are coordinated at different power levels to meet the load demand. Therefore, the fact that a generator operates at the optimal point of economic emission cost does not mean that other generators in the system also operate optimally. Therefore, the problem in finding the optimal solution to the problem of determining the structure and operation of the microgrid is how to satisfy the given conditions.

$$h = \frac{f_c(P)}{f_e(P)}$$

With $f_c(P)$ and $f_e(P)$ being the functions of fuel cost and emission cost according to the generating capacity of the device. Applying the correlation coefficient h to the problem models, h can have 5 variations to choose from including $h_{min-min}$, $h_{min-max}$, $h_{max-min}$, $h_{max-max}$, $h_{average}$. Depending on the conditions of the objective functions and the characteristics of the generator, the appropriate variation is selected. The selection of which variation of h is done automatically through programming. The algorithm for selecting the coefficient h will be integrated into the process of finding the optimal value.

1.2.2 Solving a variety of microgrid optimization problems

The thesis analyzes 5 main mathematical forms of the problem of determining the structure and optimal operation of the microgrid. From this analysis, the thesis has conducted research and found optimal solutions for 7 specific problems divided into 4 main mathematical forms. With the applied algorithms, it shows that the proposed algorithm is capable of solving complex problems in the microgrid system.

With 3 algorithms used for 7 problems divided into 4 mathematical forms with the complexity of the objective function and the constraints of the input variables, the requirements of the load, the thesis shows that the algorithms SFSA, SOSA, ISOSA are capable of meeting the requirements for optimal solutions with fast and efficient solving speed.

At the same time, to ensure full reflection of possible situations for a microgrid system, the problems in the thesis are all built according to continuous operating scenarios from 1 day to 3 weeks. The system operates in both grid-connected and grid-separated modes. For each hour/day of system operation in the case of grid separation and grid connection, the proposed algorithms give better results than other control algorithms.

1.3 Results achieved

Through the analysis of the problems and the application of the thesis's algorithms, it has been shown that the algorithms proposed by the thesis all give effective solutions. At the same time, for each operating scenario of the microgrid system, the solutions of the SFSA, SOSA, and ISOS algorithms all give fast convergence speeds. Although they are algorithms that search for relatively optimal values, the solution results of the algorithms have high stability.

The applied SFS, ISOS, and SOS algorithms all give better optimal results than other algorithms with a better rate of several percent to over 10%. The convergence speed of the algorithm is fast. In all 4 problem models, the convergence speed is within the threshold of less than 70 iterations. At the same time, each case is performed continuously 30 times to find the average value and test the stability of the solution. The results show that the solution has good stability, with a standard deviation of about 5%.

At the same time, the algorithm is an effective tool to solve complex problems quickly. The objective functions of the 4 types of math given are quadratic functions combined with transcendental functions (trigonometric functions, exponential functions, logarithmic functions), so the complexity is higher than that of polynomial functions. At the same time, the objective function operates under complex boundary conditions, so the complexity of the problem is even higher than that of normal problems. However, in all cases, the algorithms have quickly provided optimal solutions for these objective functions. The fastest convergence time with the solution obtained after solving achieves the highest accuracy. In all cases, the time to find the result ranges from 10.245s - 85.801s depending on the number of selected loops.