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An Improved Intelligent Algorithm for Solving the Unit Commitment Problem

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***Abstract* – In this paper is used to reduce the generation cost and maximize the supply reliability using two-layer binary multi objective particle swarm optimization algorithm. Unfortunately some difficulties arise when we attempt to realize the above objectives. In the current power market, system operators strive to maintain, reliability standards while minimizing the operating cost of the system. The complexity of the two-stage multi objective optimization problem makes the runtime cost is high, then to developed TLB-MOPSO algorithm can also find better spread of solutions and to reduce the iteration number.**

***Keywords* – particle swarm optimization, two-stage multi objective problem, power demand.**

I.INTRODUCTION

Unit commitment is a nonlinear mixed integer optimization problem to schedule the operation of the generating units at minimum operating cost while satisfying the demand and reserve requirements. The UCP is the control process of power system. The main objective of a two stage multi- objective unit commitment optimization problem as much as possible while satisfying future power demand. Unfortunately some difficulties arise when we attempt to realise the above objectives. One difficulty is the real demands are always affected by various factors, which can cause the predicted values to deviate from the real ones, another difficulty exist in the UCP optimization process.

To mitigate the above difficulties in this study employ two-layer binary multi objective particle swarm optimization algorithm. The main disadvantage of this algorithm is the runtime cost is high, then to developed TLB-MOPSO algorithm [3] can also find better solution compared to two- stage optimization problem. Therefore, the solution method is effective for solving the above problems and iteration number is low when compared to two stage optimization problem. The definition of preparing on/off schedule of generating units in order to minimize the total production cost of utility and constraints such as system Power balance, system spinning reserve, and unit's minimum up and down times are satisfied.

II. PRELIMINARIES

The unit commitment is defined as the selection process of generators that must be operated to meet the forecasted load demand on the system over a period of time. The unit commitment optimization problem (UCP) is one of the most important control processes of power system [1], [4]. The UCP models minimize total generation cost and maximize the supply reliability. The multi objective UCP has the following optimization methods,

- Genetic algorithm
- Mixed integer programming
- Evolutionary programming
- Lagrangian relaxation

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- Dynamic programming etc.

A . Dynamic Programming

It was the earliest optimization based method to be applied to the UC problem. It is used extensively throughout the world. It has the advantage of being able to solve problem of a variety of sizes and to be easily modified to model characteristics of specific utilities. It is relatively easy to add constraints that affect operations at an hour since these constraints mainly affect the economic dispatch and solution method. The disadvantage of the dynamic programming is its requirement to limit the commitments considered at any hour and its suboptimal treatment of minimum up and downtime constraints and time-dependent start-up costs.

B . Lagrangian Relaxation

It is considered the best to deal with large-scale unit commitment although it cannot guarantee the optimal solution. The LR technique is a mathematical tool for mixed integer programming problem. LR can provide a fast solution but the quality of solution strongly depends on the algorithm used to update the lagrangian multipliers. However, this technique suffers from convergence problem, and always gets stuck into a local optimum. In order to achieve a high quality solution, a hybrid method between LR and evolutionary strategy was used to solve the UC problem. The hybrid method is based on the classic technique LR, in which is introduced an evolutionary technique to proceed with adjustment of the lagrangian multipliers.

C. Integer Programming

The main objective is to increase the unit profit from selling both energy and spinning reserve in the spot market. It is reported that this approach overcomes the modelling limitations of DP approaches and is computationally efficient. Given market prices for energy and ancillary services, modelled the mixed integer programming based PBUC problem for a GENCO with thermal, combined - cycle, cascaded-hydro, and pumped storage units. When the market price cannot be considered as an exogenous variable, the authors propose to introduce, explicitly, the market behaviour by means of the expected hourly supply and demand functions. Operation costs included are fuel costs, shut- down costs and start- up costs.

III. SOLUTION METHOD

The above multi objective unit commitment optimization problem techniques are totally different from traditional method and it is not easy to solved. It requires much higher runtime costs than the traditional unit commitment problem. Here we employ an improved multi objective unit commitment optimization technique is called two layer binary particle swarm optimization algorithm(TLB-MOPSO) [3]. This process optimizes the unit schedule to minimize the generation cost, which can be summarized with the following formula:

$$F_i(P_{ih}) = \sum_{i=1}^{N}[a_i + b_i P_{ih} + c_i P_{ih}\text{^}2] \quad (1)$$

Where a_i, b_i and c_i are the coefficients determined by the attributes of each generator.

The cost functions F must be solved while satisfying the following constraints, which are produced by system’s objective requirements. These constraints include:

1) Power demand balance:

$$\sum_{j=1}^{N} P\, j^i .\, uj^i = P_i \quad (2)$$

Where P_i is the power demand of period i.

2) Spinning reserve requirement:

$$\sum_{j=1}^{N} P\max^j .\, uj^i \geq P_i + R_i \quad (3)$$

Where R_i is the spinning reserve of period i.

3) Generation constraints:

$$P_{min} j .\, u_i j \leq P_j i \leq P_{max} j .\, u_i j \quad (4)$$

Where $P_{max}j$ and $P_{min}j$ are the maximum and minimum generation capacity of unit j.

4) Unit ON/OFF Limitations:

The unit should be kept on for certain hours before it can be changed.

$$T_{jon}^{i} \geq T_{j,up}$$
$$T_{joff}^{i} \geq T_{j,down} \quad (5)$$

Respectively, T_{jon}^{i} and T_{joff}^{i} record the amount of time that unit j has been turned on or off at period i. $T_{j,up}$ and $T_{j,down}$ are the constraints on the minimum on and minimum off time of unit j, which are determined by the attribute of each generator.

A . Proposed TLB-MOPSO

In PSO algorithm, the population has n particles and each particle is an m-dimensional vectors, where m is the number of optimized parameters. From [6] and [7] incorporating the above modifications, the computational flow of PSO technique can be described in the following steps

Step 1: Initialization

- Set the time counter t=0 and generate randomly n particles, [$X_j(0)$, j=1,...n], where $X_j(0) = [x_{j,1}(0),\ldots,x_{j,m}(0)]$.
- $X_{j,k}(0)$ is generated by randomly selecting a value with uniform probability over the kth optimized parameter search space [xk min,xk max].
- Similarly, generate randomly initial velocities of all particles,[$v_j(0)$, j=1,…n], where $v_j(0)=[v_{j,1}(0),\ldots,v_{j,m}(0)]$
- $X_{j,k}(0)$ is generated by randomly selecting a value with uniform probability over the k^{th} optimized parameter search space [x_{kmin}, x_{kmax}].
- Similarly, generate randomly initial velocities of all particles, [$v_j(0)$, j=1,..n], where $v_j(0)=[v_{j,1}(0),\ldots, v_{j,m}(0)]$.
- $v_{j,k}(0)$ is generated by randomly selecting a value with uniform probability over the k^{th} dimension [$-v_{k\,max}$, $v_{k\,max}$].
- Each particle in the initial population is evaluated using the objective function *J*.
- For each particle, set $X_j^*(0) = X_j(0)$ and $J_j^*(0) = J_j(0)$, j = 1…n Search for the best value of the objective function J_{best}.
- Set the initial value of the inertia weight w (0).

Step2: Time Updating

Update the time counter t = t+1

Step 3: Weight Updating

Update the inertia weight w (*t*)= $\alpha\, w(t-1)$

Step 4: Velocity Updating

Using the global best and individual best of each particle, the j^{th} particle velocity in the k^{th} dimension is updated according to the following equation.

$$V_{j,k}(t) = W(t)V_{j,k}(t-1)+ c_1r_1((t-1)- x_{j,k}(t-1))+ c_2r_2((t-1)- x_{j,k}(t-1) \quad (6)$$

Where and are positive constants and and are uniformly distributed random numbers in [0, 1]. It is worth mentioning that the second term represents the cognitive part of PSO where the particle changes its velocity based on its own thinking and memory. The third term represents the social part of PSO where the particle changes its velocity based on the social-psychological adaptation of knowledge.

Step 5: Position Updating

Based on the updated velocities, each particle changes its position according to the following equation:

$$X_{j,k}(t) = V_{j,k}(t) + X_{j,k}(t-1) \quad (7)$$

If a particle violates its position limits in any dimension, set its position at Proper limit.

Step 6: Individual Best Updating

Each particle is evaluated according to its updated position. If $J_j < J_j^*$, j =1,…,n , then update individual best as (t) = X_j (t) and= J_j and go to step 7; else go to step7.

Step 7 : Global Best Updating

Search for the minimum value J_{min} among, where min is the index of the particle with minimum objective function, i.e min ϵ {j; j = 1,…,n}. If $J_{min} < J^{**}$, then update global best as (t) = X_{min}(t) and = J_{min} and go to step8 else go to step 8.

Step 8 : Stopping Criteria

If one of the stopping criteria is satisfied then stop; else go to step 2.

IV.RESULT

A . Minimization Of Generation Cost Using TLB-MOPSO

The objectives of the MO-UCP are considered to maximize the supply reliability and minimize the total generation cost, under the uncertain load forecasting. Different distributed fuzzy variables were used to more accurately describe the future power loads, and the concept of maximal blackout time was developed as a new approach to evaluate the power supply reliability in an uncertain environment. Furthermore, as a solution approach to this model, an improved two-stage multi-objective particle swarm optimization algorithm is designed.

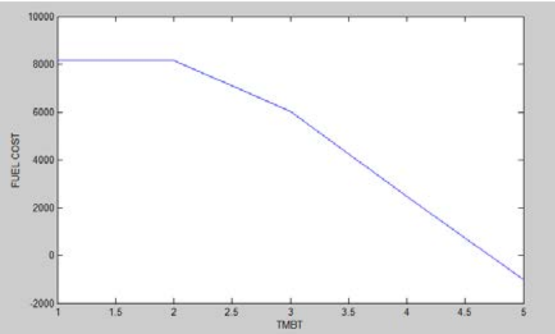

Fig 1. Plot between TMBT and Generation Cost

B. Advantages of PSO technique

The advantages of PSO technique over traditional unit commitment optimization model:

1. It can be simply planned and customized with fundamental arithmetic and logical functions.
2. It is economical in terms of calculation time and remembrance.
3. It is capable of being incorporated easily with other optimization tools to shape hybrid ones.
4. It is less susceptible to a superior premature solution because it is a population – based method.
5. It can easily deal with non-differentiable objective functions because PSO uses payoff (performance index or objective function) information to guide the search in the problem space.

V.CONCLUSIONS AND FUTURE WORKS

The proposed method has two- stage multi-objective optimization model is used to solve the unit commitment problem and reduce the total generation cost. The result shows the solution of MO-UCP is able to minimize the total generation cost in the system. Another Multi dynamic programming algorithm is used to minimize the generation cost and compare with PSO. This method will improve both the mathematical model and the solution method to handle the optimization problem of multi-node system.

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