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Analysis of Economic Load Dispatch with Ramp Rate Limit Constant using Hybrid BSA-PSO Algorithm

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***Abstract*— In the electric power industry, an efficient and optimally economic operation is always an important factor. In the operation, control, management and planning of power systems, the dispatch of electrical load is the main function which further reduces the total cost of generating units with regard to considered constraints. Application of the hybrid BSA-PSO algorithm for economic load dispatch problem is presented here. A new hybrid optimization, BSA-PSO, is known for backtracking search algorithm & particle swarm optimization. Recently various techniques for soft computing have been applied. This paper suggested a hybrid BSA-PSO algorithm method to solve economic load dispatch problem. Valve point effect is considered with cost function.**

Keywords- economic load dispatch, BSA-PSO, valve point effect

I. INTRODUCTION

Economic load dispatch (ELD)'s primary role is to ensure the most efficient operation of the power grid generation system. The main goal of the ELD is to reduce the cost of generating fuel. A widespread research field is the minimum cost function found through optimization techniques. ELD and optimal power distribution are a major part of the various problems in the operation of the energy system.

The output energy of the unit or unit manufactured to carry the given load in a way that minimizes the total fuel cost is referred to as the ELD. Each generator will use specific cost coefficients of each unit to determine the cost of generation. ELD's main objective is to share the energy among the participating production units to meet demand needs and to reduce production costs. If the transmission loss is ignored, the sum of the total power generated is the same as the pre-compulsory power. This will greatly facilitate the solution process. The ELD decision is difficult if transmission losses are included in the process. Then we must find another way to find the solution.

Literature survey shows that ELD problems have been solved over the years by using various system forms. A few strategies are shown below.

The bat algorithm [1] is one such type of optimization. The new Bat algorithm was introduced in this communication to solve the ELD problem. The novel bat algorithm introduces the idea to use Doppler Effect and move bats across various habitats. The most effective of them is equivalent to the Bat algorithm and the PSO. The novel bat algorithm introduces the idea that bats between different habitats should be used with Doppler Effect. The most successful of these is contrasted with the Bat algorithm and PSO. Testing it on 5-and 6-unit systems demonstrates the effectiveness of the proposed method.

The article proposes BSA [2] algorithm for solving ELD where prohibited zone was considered for generation of thermal power. ELD is a major problem in optimisation. Currently, problems of ELD have been resolved through many types of computer technology. The BSA methodology was used to evaluate 15 unit test systems and to solve them. PSO, PSO with constriction factor approach, PSO with inertia weight approach and PSO with constriction factor and inertia weight approach are equivalent to the optimal fuel cost applied to the BSA methodology.

The ion motion optimizing (IMO) [3] to resolve the power system problem of non-Convex ELD is implemented in this article. The Ion motion optimisation concept is based on the attraction and repulsion forces in the real world between the anions and cations. The IMO mathematical model is easy to implement and quiet. The liquid phase of IMO simulates the exploitation and the exploration. The external penalty method is used to manage the power balance equality limit. Finally, ELD with 13 generators can be resolved by optimizing ion movement.

The ELD [4] with dynamic approach in micro grid systems is favoured over the static approach because it not only reduces costs, but also helps to manage distribution generators (DGs). This paper developed a model of micro grid system comprising diesel engines (DE), wind turbines (WT), a fuel cell (FC) and a battery, taking into account the effect of reserve, emissions, renewable power fluctuations and price variation in network. The main goal is to reduce the cost of operation and treatment for pollutants. For two operating modes connected to the grid and the island mode, a micro grid analysis is done on four different schedule scheme. The energy and cost analysis of each schedule is performed in depth using the GAMS program with MATLAB interfacing. The DGs or the main grid will be given priority in grid-connected mode to exchange power between grid and micro grid. Battery is used for economic load dispatch in island mode instead of the grid.

The Economic Load Shipment system means low cost electricity generation and the electricity systems constraints including real power and reactive power differ within the stated limit while meeting the power system load requirements. Total operating costs include fuel costs, transmission costs, labour and maintenance costs. The cost of generation and the amount of power supplied are two major factors to consider when supplying electricity to generating units. In a polynomial equation the relation between the cost of generation and the supplied amount of power is expressed and solved by the application of a mathematical technique. In finding optimal solutions, the suggested optimisation techniques are worthwhile. Here genetic algorithm [5] and simulated algorithm essentially in this study paper. The IEEE 30 bus system and the 20-unit generation method has been checked with the algorithm used.

With the optimal scheduling of the strength cycle, the operation of economic power systems or structures is achieved by fulfilling the load requirement. ELD is a strategy to reduce the overall cost of real energy generating at various power plants while meeting heaps and disadvantages in the transmission line. Various methods for ELD are employed. Most of the methods that exist are either very complex or do not do well to reduce costs. Previously, the desired energy flow problems are addressed with various traditional optimisation calculations. In order to provide buyers with safe and reliable capability at a price, a technique is introduced in the designing and task of intensity frameworks. This paper proposes a mine blast algorithm (MBA) [6] to overcome the ELD problem. The main concept of the MBA consists of spreading the shrapnel pieces with different speeds and times in different ways and exploding the next time the shrapnel collision with the next mine happens within a certain region. This simulation is better or comparable than the well-established and common algorithm for the proposed algorithm.

In the operation and control of the power system, the ELD [7] plays an important role. To solve these problems various techniques have been used. Soft computing technologies have recently been used extensively in practical applications. The paper shows the successful application of four evolutionary algorithms: particle swarm optimisation (PSO), constrictive factor optimization (PSOCFA), inert weight factor inertia optimization (PSOIWA) and constriction factor inert component swarm optimizing (PSOCFIWA). In order to resolve this problem, cap ramp-rate limit limits are proposed.

ELD [8] for energy generation and distribution in electricity systems is one of the key issues. For this reason, the ELD problem is influenced by different techniques for optimisation. This paper suggests and is used to resolve ELDs by means of the vortex search algorithm (VSA). By observing the moving state of liquids, the VSA method was developed by nature. The VSA method is considered to solve the problem of ELD in terms of transmission losses, valve point load effect, ramp rate limits and prohibited area' restrictions.

This approach is shown to be feasible and efficient in various cases. Results obtained are compared with various algorithms developed and these results clearly show that the proposed VSA method delivers results successfully.

The new evolutionary algorithm is BSA [9] algorithm. It is an evolutionary algorithm for population-based solutions to problems of global optimisation. It has a different structure, like processes of selection, mutation and crossover. This arrangement means that the BSA can use data from the entire population and maintain high levels of demographic diversity. Although all these activities are conducted spontaneously and have no purpose, BSA cannot guide people to search for the area that has been found to offer better solutions.

The purpose of the present paper is to minimize the energy consumption of both PFSP and makeup by a hybrid backtracking search (HBSA) [10]. In HBSA, simulated annealing (SA) is hybrid and originally used as a backtracking search to update the population. We evaluate the efficiency of initialization, transformation and mutation and use efficient strategy to boost its performance taking into consideration the effects of various operators on BSA.

Here we have used fifteen unit test system and applied hybrid BSA-PSO algorithm. We also compare the result of BSA-PSO hybrid algorithm with different algorithm like PSO and found that hybrid BSA-PSO algorithm has better efficiency than the old algorithm.

II. Problem Formulation

The ELD dilemma was designed to limit all costs of fuel while respecting the limits.

A. *Objective function*

The quadratic function is used to estimate the fuel capacity of each thermal power unit. As far as real power generation is concerned, complete costs can also be communicate

$$\min f = \sum_{i=1}^{n} a_i P_i^2 + b_i P_i + c_i \quad i = 1,2,3......,n \tag{1}$$

where the amount of units produced is n.

B. *Constraints*

(i) Power balance constraints

The power generated should be equal to the total demand for load P_D (in MW). The equalization of the active power is given here

$$P_D = \sum_{i=1}^{n} P_i \tag{2}$$

Losses in the generator and transition are ignored

(ii) Generation limits

The output power of each generator has a top and bottom relation to lie among these borders.

$$P_i^{\min} \le P_i \le P_i^{\max} \tag{3}$$

(iii) Ramp-rate limit constraints

$$\max\left(P_i^{\min}, P_i^0 - DR_i\right) \le P_i \le \min\left(P_i^{\max}, P_i^0 + UR_i\right) \tag{4}$$

III. BSA-PSO Hybrid optimization

BSA is Backtracking search algorithm as well as population dependent algorithm. This BSA algorithm was suggested by Pinar Civicioglu in 2013. Eberhart and Kennedy proposed PSO in 1995. PSO is also an algorithm based on population. BSA and PSO are common techniques of optimization. The tuning parameters have their own, and produce good performance. All BSA and PSO have a good character in convergence. Optimizing hybrid BSA-PSO is a new technology, very stable, simple and effective. Five steps comprises of Initialization, Selection-I, Mutation, Crossover and Selection-II. Initialization consists of PSO. This defines the locations and velocities of gbest & pbest particles and re-combines them

IV. Implementation Of Hybrid BSA-PSO In Eld Problem

The BSA-PSO [11] hybrid approach incorporates the best of the BSA and PSO criteria, producing integration and an optimum outcome. BSA and PSO are common initialization measures. Components are randomly generated using the formula under their generation limits.

$$P_{i,j} \sim U\left(low_j, up_j\right) \tag{5}$$

Where $i = 1,2,3,\ldots\ldots, N$ and $j = 1,2,3,\ldots\ldots, D$

The particle fitness cost is measured using objective function and particle volume (variables) is initialized as pbest(s).

For Section-I phase, particles are randomly regenerated with equation (6) within their so-called old population.

$$oldP_{i,j} \sim U\left(low_j, up_j\right) \tag{6}$$

Use formula (7), g and h produce equivalent real numbers 0 and 1. Since forming of the old population, denoted with old P.

$$\text{if } g < h \text{ then } oldP := P \mid g, h \sim U\left(0,1\right) \tag{7}$$

Reformed oldP is permutated using equation (13).

$$oldP := permuting\left(oldP\right) \tag{8}$$

Permutation is altered spontaneously when permutation is over. Selection-I is done in this direction.

At the conclusion of selection-I, the mutation process begins. At this point, a formula mutation is used (9). Formula (9) is used to produce mutation representatives.

$$mu\tan t = P + F \times \left(oldP - P\right) \tag{8}$$

Here F is seen as a random value producing 0 and 1, respectively.

After the fusion stage, the convergence process begins. During this process, mutant quality for the trail community (T) is first regarded. For crossover segment, the final form of sample population is called. Crossover consists of two phases originally. The first step is to modify the value of T using P values with the binary-integer matrix array.

if $map_{n,m} = 1$,

Where $n \in \{1,2,3,\ldots\ldots, N\}$ and $m \in \{1,2,3,\ldots\ldots, D\}$, T is updated with $T_{n,m} := P_{n,m}$.

Stage two is the final stage for the crossover. The final trail particles have fitness values measured using objective method in this level.

Velocities and positions of particles produced at the initial stage are respectively modified with formulas (9) and (10). And they're 2.05.

$$v_{id}^{(k+1)} = w \times v_{id}^{(k)} + C_1 \times rand \times \left(pbest_{id} - x_{id}^{k}\right) + C_2 \times rand \times \left(gbest_{id} - x_{id}^{k}\right) \tag{9}$$

$$x_{id}^{(k+1)} = x_{id}^{k} + v_{id}^{(k+1)} \tag{10}$$

Use formula (1), new fitness values of the modified particle location are evaluated. Such new fitness values for modified particle locations are contrasted with the last particle fitness values according to the maximum particle health rating.

The BSA-PSO Hybrid Algorithm Selection-II is the final stage. In this step pbest or initialized particles are being measured and substituted according to their best fitness values by current particles. Pbest is regarded as the best quality. The gbest patch is the best worldwide. Optimum results appear otherwise in the first case when the parameters were halted.

V. Results of Simulation

The BSA-PSO hybrid algorithm was set with ELD. In this we use fifteen unit evaluation systems to solve ELD problems with the hybrid BSA-PSO algorithm. The reliability of the proposed method was tested in a case study on ELD problems. The calculation of population= 50, the most extreme iteration= 500 was taken into consideration. Statistics are shown in Table I for 15 thermal units which produce power and price coefficients. The optimized energy generation for fifteen generators and their cost are given in Table II. Proposed algorithm convergence actions i.e. **Figure1** displays BSA-PSO for ELD issue.

A. ***Case study I:*** *Fifteen-unit system*

It is made up of 15 thermal units. Here every heat units are inside greatest and least creating points of confinement. Coefficients of fifteen warm units and the producing unit limit are given in Tables I. The load demand is $P_D = 2630$ MW for this situation.

Table I: Fifteen heat generating units generate ability and fuel price coefficients.

Unit	P_i^{min}	P_i^{max}	p_i^0	UR_i	DR_i	a_i	b_i	c_i
1	150	455	400	80	120	0.0003	10.10	671
2	150	455	300	80	120	0.0002	10.20	574
3	20	130	105	130	130	0.0011	8.80	374

4	20	130	100	130	130	0.0011	8.80	374
5	150	470	90	80	120	0.0002	10.40	461
6	135	460	400	80	120	0.0003	10.10	630
7	135	465	350	80	120	0.0004	9.80	548
8	60	300	95	65	100	0.0003	11.20	227
9	25	162	105	60	100	0.0008	11.20	173
10	25	160	110	60	100	0.0012	10.70	175
11	20	80	60	80	80	0.0036	10.20	186
12	20	80	40	80	80	0.0055	9.90	230
13	25	85	30	80	80	0.0004	13.10	225
14	15	55	20	55	55	0.0019	12.10	309
15	15	55	20	55	55	0.0044	12.40	323

Table II: Optimal power and generation cost of fifteen generators

Unit of power output	BSA-PSO (Proposed)	PSO[7]
1	280.0000	455.0000
2	180.0000	380.0000
3	571.0572	130.0000
4	571.0572	129.9997
5	150.0000	170.0000
6	280.0000	460.0000
7	392.8856	430.0000
8	60.0000	60.0000
9	25.0000	40.0001
10	25.0000	160.0000
11	20.0000	80.0000
12	20.0000	80.0000
13	25.0000	25.0000
14	15.0000	15.0002
15	15.0000	15.0000
Total cost($/hr)	31,605	32,359

Table III: Comparison of total costs of four results

Algorithms	Optimal fuel cost ($/Hr.)
BSA-PSO (Proposed)	31605.00
PSO[7]	32,359.00

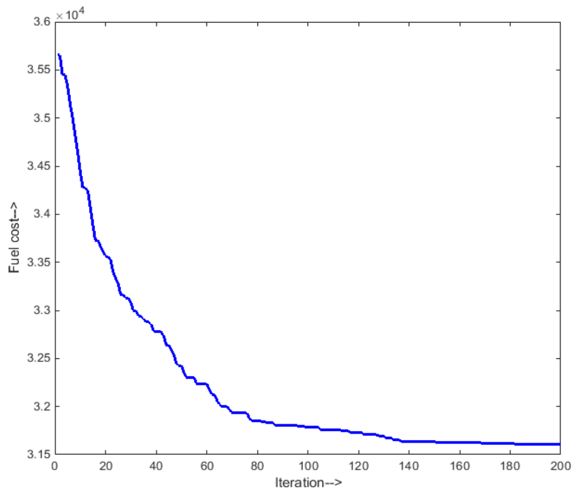

Fig. 1: BSA-PSO convergence behaviour for 15 unit test system

VI. Conclusion

A new hybrid algorithm i.e. BSA-PSO algorithm has been proposed and implemented for solving ELD problem where different linear and nonlinear constraints are considered. 15 unit test system has been considered. Here, ramp rate limit constraint has been considered. Effectiveness of proposed algorithm has been shown by comparing with the results of PSO. Test results show that BSA-PSO hybrid optimization is better than other strategies for consistency of the solution and strong convergence properties.

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