IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 4 Issue 9, September 2017
ISSN (Online) 2348 – 7968 | Impact Factor (2016) – 5.264
www.ijiset.com

Solving Economic Dispatch Problems By Using Grey Wolf Optimization Technique

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ABSTRACT

The Economic dispatch (ED) is of vital importance since it doesn't only reduces the operation cost of the generation utility but also helps in conserving fast dwindling energy resources. They are many researches that have been developer to minimize fuel cost based on swarm intelligence also.The Swarm Intelligence algorithms preserve information about the search space over the course of iteration, whereas evolutionary algorithms (EA) discard the information of the previous generations. SI algorithms have fewer operators compared to evolutionary approaches. This paper discussed some issues of Swarm Intelligence techniques for a new meta-heuristic and product Grey Wolf Optimizer (GWO) inspired by grey wolves(Canis lupus). The efficiency and effectiveness of the proposed technique is benchmarked for different test cases consisting of three, six for generating units with high non-linearity. The results of the GWO compared with that of other intelligence optimization algorithms in terms of operating cost of generators and power generation. Wide contrasting simulation results are observed with the other swarm, nature and bio inspired algorithms.GWO results in minimum operating cost, minimum standard deviation among best, mean and worst solution showing good exportability, fast convergence with iteration leads to robustness and good solution quality.

Index Terms

Economic dispatch (ED); Grey Wolf Optimization (GWO).

1. INTRODUCTION

The main aim of power system supply utility has been identified as to provide the smooth power generation system to the consumers. It will be ensured that the electrical power is generated with minimum cost. That is mean to achieve an economic operation of the power system; the total demand must be appropriately shared among the units. This will minimize the total generation cost for the power system with the voltage level maintained at the safe operating limits. Economic dispatcher defined as the process of allocating generation levels to the generating units in the mix so that the system load is fully supplied in the most economical way. The method of economic dispatch for generating units at different loads must have total fuel cost at the minimum point.

Meta-heuristic classified into three main classes are evolutionary, physics-based and swarm intelligence(SI). SI includes Particle Swarm Optimization (PSO), Artificial Bee Colony (ABC), Cuckoo Search (CS) and Firefly Algorithm (FA) techniques. Many of these techniques are inspired by hunting and search behaviors. To the best of our knowledge, however, SI does not support grey wolves known by pack hunting; this motivated our attempt to mathematically model the social behavior of grey wolves in solving benchmark and real problem.Grey wolf is a new population based method which is introduced in 2014 by Mirjalili et al. GWO algorithm is inspired by grey wolves. The technique follows the social hierarchy and hunting path of grey wolves

Inspiration: The GWO are mostly preferred to live in a pack. Our group size is 5-12 on average. The particular interest is that they have a very strict social dominant hierarchy as shown in Fig. 1.

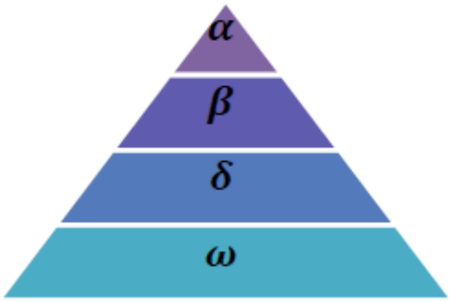

Fig 1:Hierarchy of grey wolf

The follow-up of grey wolf hunting are:

• Tracking, chasing, and approaching the victim.

• Pursuing, encircling, and harassing the victim until it stops moving.

• Attack towards the victim.

These steps are shown in Fig 2.

Fig 2.Hunting behaviour of grey wolves: (A) chasing, approaching, and tracking prey (B, C, D) pursuiting, harassing, and encircling(E) stationary situation and attack

In this paper we take three units and test power generation by applying newmeta-heuristictechnique calledGrey Wolf Optimization (GWO) for solve the problem of economic load dispatch by minimize fuel cost for unit generation, The GWO is inspired by grey wolves(Canis lupus). The GWO algorithm mimics the leadership hierarchy and hunting mechanism of greywolves in nature. Four levels of grey wolves such as alpha, beta, delta, and omega that work in a hierarchyare employed for simulatingthe leadership hierarchy. In addition, there are three main steps of hunting, searching for prey, encirclingprey, and attacking prey, are implemented.

2. METHODS

2.1. PROBLEM FORMULATION

The ED problem may be stated as to reduce the fuel cost of generator units with several constraints. Mathematically, it may express as:

A) Economic dispatch problem (Minimization of Fuel Cost)

Fuel cost model

Subjected to following constraints

Where,

,

,

This equation is about how extract the minimal fuel cost by choosing the best power generation which we take average of minimal power generation and maximum power generation to reach into best generation and minimal fuel cost,

.

2.2. Grey Wolf Optimization

2.2.1.Mathematical model and algorithm

Social hierarchy: For modeling the social hierarchy of wolves until designing GWO, the fittest solution is considered as the alpha (α). Accordingly, the second and third best solutions are named beta (β) and delta (δ) respectively. The rest of the candidate solutions are considered to be omega (ω). The w wolves follow these three wolves.

Encircling prey: Next, for designing encircling behavior, some equations are considered:

$D= (C.\ X_p(t)-X(t))$

$X\ (t+1) = X_p(t)-A.D$

Where(t) is the current iteration, A and C are coefficient vectors, $X_p(t)$ represents the position vector of the victim. The vectors A and C can be calculated as below:

$X=2.a.r1-a$

$C=2.r2$

Where component of a are linearly decreased from 2 to 0 over the course of iterations and r1 and r2 are random vectors in the range [0, 1]

Hunting: In GWO, the first three best solutions obtained are stored so far and push the other search agents (including the omegas) to update their positions due to the position of the best search agents. The following equations are modeled.

The final position would be in a random position within a circle which is defined by the positions of alpha, beta, and delta in the search space.

3. Results and Discuss

3.1. Algorithms Numerical Settings

GWO: Population size =50, coefficient a=[0-2],Iterations=500

3.2.TheMetrics of Generation that we used in explain are as follows:

MW: Mega Watt of Power Generation
PG_{min}(MW): Minimum Power Generation
PG_{max}(MW): Maximum Power Generation

3.3. Approach of Power Demand Formulation Using GWOVariables

Power Generation (PG) and cost coefficients (a,b,c) of units with fitness function as fuel cost, quadratic in nature and valve point effect .

Constraints

Equality Constraints: Power Generation-Power Demand=0(P_G=P_d)

In-Equality Constraints: Power Generation should be between minimum and maximum limit of power generation.

Stopping Criteria

It is the maximum number of iteration for optimum solution.

3.4. Test System Data

To check the effectiveness of GWO for ED problems, two different case studies are taken.

Table 1: Three generating unit system data

Unit	a($/MW2)	b($/MW)	c($)	PG_{min}(MW)	PG_{max}(MW)
1	0.008	7	200	10	85
2	0.009	6.3	180	10	80
3	0.007	6.8	140	10	70

Table 2: Six generating unit system data

Unit	a($/MW^2)	b($/MW)	c($)	PG_{min}(MW)	PG_{max}(MW)
1	0.007	7	240	100	500
2	0.005	10	200	50	200
3	0.009	8.5	220	80	300
4	0.009	11	200	50	150
5	0.0080	10.5	220	50	200
6	0.0075	12	120	50	120

3.5.Numerical Result

The proposed technique is tested on different benchmarks for simulation. Comparative analysis is demonstrated with other optimization techniques

Table 3: Results comparison with other techniques and cost (Power Demand-150 MW)

Parameters	GWO	CS	ABC	FA
PG1(MW)	550.55	33.490	33.049	32.729
PG2(MW)	481.725	64.116	61.764	63.843
PG3(MW)	423.2	55.126	57.872	56.151
Cost($/hr)	**1455.475**	**1600.46**	**1600.51**	**1600.47**

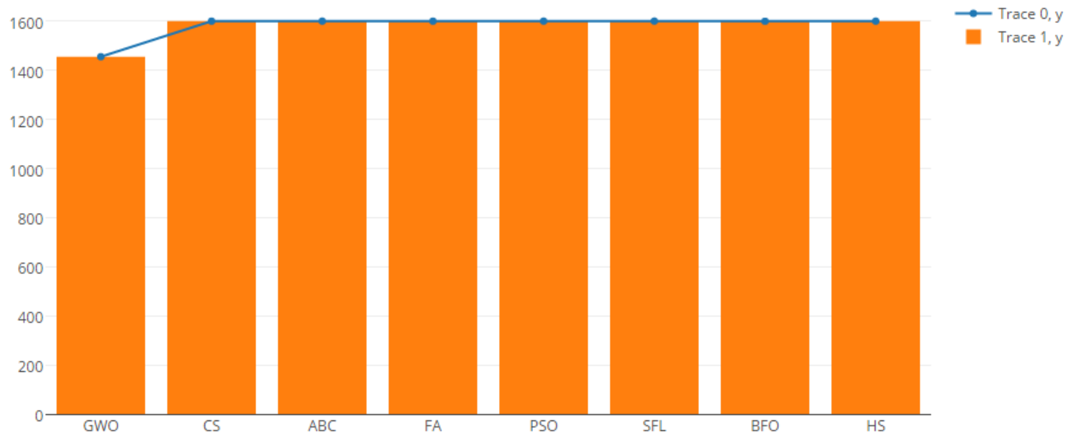

Fig 3: Comparison of Total cost of GWO with other techniques on three units

Table 4: Result comparison of different technique cost for six units

Techniques	**GWO**	CS	ABC	FA	PSO	SFL	BFO	HS
Cost($/hr)	**7804.603125**	8356.06	8372.27	8388.45	8401.45	8419.78	8428.69	8398.06

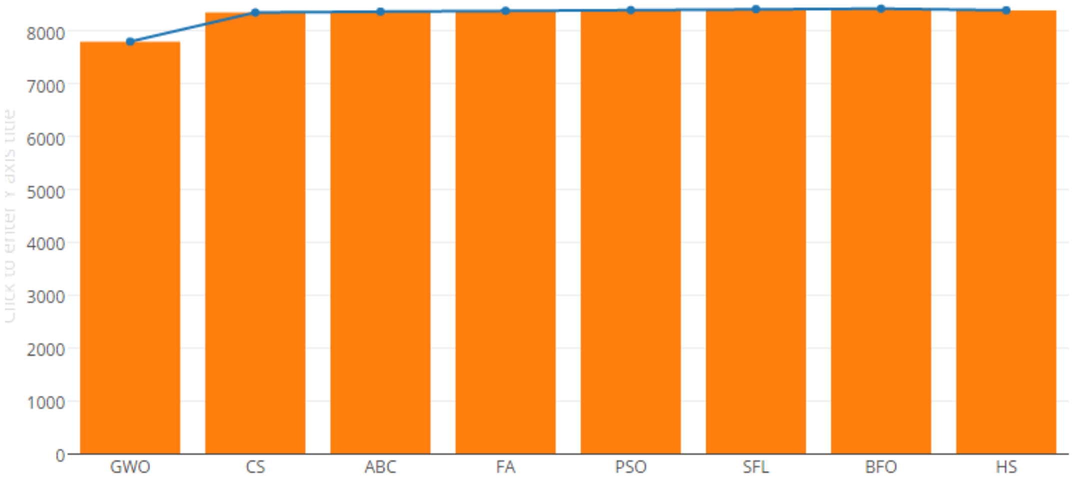

Fig 4: Comparison of Total cost of GWO with other techniques on six units

CONCLUSION

In this paper we discuss the Economic dispatch (ED) aims at distributing the load demand between all of various generation units in an electrical system such that the total cost of generation is very minimum. We were used some equations in Swarm Intelligence techniques for a new meta-heuristic called Grey Wolf Optimizer (GWO) inspired by grey wolves(Canis lupus) to solved problem of ED. The GWO algorithm mimics the leadership hierarchy and hunting mechanism of greywolves in nature.It proposes an effective and reliable Grey Wolf Optimization (GWO) technique for the economic load dispatch problem. The efficiency and effectiveness of the proposed technique is benchmarked for different test cases consisting of three, six for generating units with high non-linearity. The results of the GWO compared with that of other intelligence optimization algorithms in terms of operating cost of generators and power generation. Wide contrasting simulation results are observed with the other swarm, nature and bio inspired algorithms.GWO results in minimum operating cost, minimum standard deviation among best, mean and worst solution showing good exportability, fast convergence with iteration leads to robustness and good solution quality.

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