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Chicken Swarm Optimization for Economic Dispatch with Disjoint Prohibited Zones Considering Network Losses

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Abstract: *Economic dispatch problem is one of the optimization problems in power system. This paper attempts to investigate the applicability of Chicken Swarm Optimization algorithm (CSO) to solve extremely challenging non-convex economic load dispatch problem with valve point loading effect, prohibited operating zones, ramp-rate limits and transmission losses involving variations of consumer load patterns. The performance of the proposed approach CSO has been tested successfully on the standard 6-unit system and 15-unit test systems with several heuristic load patterns. The results of this study reveal that the proposed approach is able to find appreciable economical load dispatch solutions than some recently published results. Besides this, the transmission line losses are also considerably reduced and the computation time is reasonably even and less when compared to other methods.*

Keywords: *Economic dispatch, chicken swarm algorithm, ramp-rate limit, prohibited zones*

I.INTRODUCTION

In modern civilization electric power system and their operation are among the complex problems due to highlynon-linear and computationally difficult environments .The basic requirement of Economic Dispatch (ED) is to generate sufficient power at the lowest cost. The ED allows to optimum generation of generating units in a interconnected power system to minimize the cost of generation, subjected to relevant system constraints. While obtaining optimum generation schedules, several constraints such as power balance constraints, capacity limit constraints, ramp-rate limits, prohibited zone sand spinning reserve constraints are to be considered. The ED can be divided into Static Economic Dispatch (SED) and Dynamic Economic Dispatch (DED). The SED allocates the load demand which is constant for a specified time interval. The DED is an extension of static economic dispatch problem. It determines the optimal generation schedule of online generators outputs with predicted load demand over a time horizontal satisfying the unit and system constraints .Big-m based MIQP method [1], MODIFIED particle swarm method [2],The demerit of Newton-based method is the convergence characteristics that are sensitive to initial conditions, linear programing method[9],In MIQP quadratic programming[1]-[11] convergence are fast, results are not at all accurate were used earlier to overcome the ELD problems. In frog leaping algorithm method[3],Constraints always increase the cost of a solution. The Lagrange multipliers give the incremental cost of the continuous constraints at the optimum. These are the mathematical techniques and have negatives of multiple local points in the cost function. There are many solutions applied for economic load dispatch problem based on the application of the artificial intelligence techniques. Such several methods are genetic algorithm mutation operators[11],it find optimal solution ,but suffer from premature convergence., DE and particle swarm optimization[8]-[9],differ evolutionary programming method [10]. Optimizing the fuel cost power is done generation from the generators. In this work, ELD is in achieved by considering the quadratic cost function. The bio inspired Algorithm- Chicken swarm optimization algorithm (CSO) is used for optimally setting the values of the control variables. The CSO is a recently developed algorithm and is with less number of operators. The algorithm can be coded in any programming language easily. Chicken swarm Optimization Algorithm was put forward by Taiwanese scholar Pan. It is a new optimization behaviors and most researchers used this algorithm for many optimization problem. Chicken swarm are superior to other species in terms of Sound echo.Rooster would emit a loud call when other chicken from a different group invade their territory. They may also spot with their sharp vision food or a place where their companions gather. The proposed algorithm is to be tested on the standard IEEE-6-unit and 15-unit bus test system and the results are expected to be better than that those of the other algorithms reported in the literature.

II.PROBLEM FORMULATION

The total cost of operation of generators includes fuel, and maintenance cost but for simplicity only variable costs need to consider are fuel costs. The fuel cost is Important for thermal power plants. The cost function is taken as a quadratic curve.

$$F = \sum_{i=1}^{N} C_i(P_{Gi}) = \sum_{i=1}^{N} a_{i+}b_iP_{Gi+}\,c_iP_{Gi}^2 \qquad (1)$$

Where *NP* is the total number of generation units, a_i, b_i, $c_i$is the cost coefficients of generating unit and P_{Gi} is the real power generation of i^{th}unit. *i=1, 2 …* to *NP*. Subject to the satisfaction of the power flow equations and the following inequality constraints on generator power, voltage magnitude and line power flow.

Subject to the following constraints:

2.1 **Equality Constraints:**

$$\sum_{i=1}^{m} \boldsymbol{P_i} = \boldsymbol{P_D} + \boldsymbol{P_L} \qquad (\mathbf{2})$$

Where

P_D is the demand power and P_L is the total transmission network Losses $\mathbf{P_i}$ generation.

2.2 **Inequality Constraints:**

Ramp-rate limit:

max(P_i^{min},P_i^0-DR_i)≤ $P_i \le min\ (P_i^{max}, P_i^0 + \mathrm{U}R_i)$

(3)

Prohibited operating zones:

$$P_i \in \begin{Bmatrix} P_i^{min} = P_{i,1}^{min} \le P_i \le P_{i,1}^{max} \\ P_{i,2}^{min} \le P_i \le P_{i,2}^{max} \\ P_{i,j}^{min} \le P_i \le P_{i,j}^{max} = P_i^{max} \end{Bmatrix} \qquad (4)$$

Where, k is the number of prohibited zones of unit i. $\mathrm{P}_{i,K}^{l}$ and $\mathrm{P}_{i,K-1}^{u}$ are the lower and the upper bounds of the kth – prohibited zone of unit i and ni is the number of prohibited zones of i. Each generator has its generation capacity, which cannot be exceeded at any time.

III. CSO ALGORITHM

Chicken swarm Optimization Algorithm was put forward by Y.TAN scholar Pan. It is a new optimization method based on chicken swarm foraging behaviors and most researchers used this algorithm for many optimization problem. Chicken swarm are superior to other species in terms of sound emit by loud call. By roosters instruction in swarm ,group of chicken. They may also spot with their food or a place where mother hens and chicks their companions gather. chicken swarm foraging characteristics have been summarized and programmed into the following steps, which are:

ALGORITHM

STEP 1:Initialization:In the chicken swarm, there exist several groups. Each group comprises a dominant rooster, a couple of hens, and chicks.$x_{i,j}^{t+1} = x_{i,j}^{t} * \left(1 + Randn(0, \sigma^2)\right)$ (3.1)

To divide the chicken swarm into several groups and determine the identity of the chickens (roosters, hens and chicks) all depend on the fitness values of the chickens themselves. The chickens with best several fitness values would be acted as roosters, each of which would be the head rooster in a group.

Step 2: assigning and determining the chicks in random position

The chickens with worst several fitness values would be designated as chicks. The others would be the hens. The hens randomly choose which group to live in. The mother-child relationship between the hens and the chicks is also randomly established.

$$\sigma^2 = \begin{Bmatrix} 1\,,\ if\ f_i \le f_k, \\ exp\left(\dfrac{f_k - f_i}{|f_i| + \varepsilon}\right), \\ otherwise \\ k \in [1, N]\,, k \ne i \end{Bmatrix} \qquad (5)$$

The hierarchal order, dominance relationship and mother-child relationship in a group will remain unchanged. These statuses only update every several (*G*) time steps.

$$x_{i,j}^{t+1} = x_{i,j}^{t} * S1 * Rand * \left(x_{r1,j}^{t} - x_{i,j}^{t}\right) + S2 * Rand * \mathrm{t} \qquad (6)$$

$$\left(x_{r2,j}^{t} - x_{i,j}^{t}\right) = t \qquad (6.1)$$

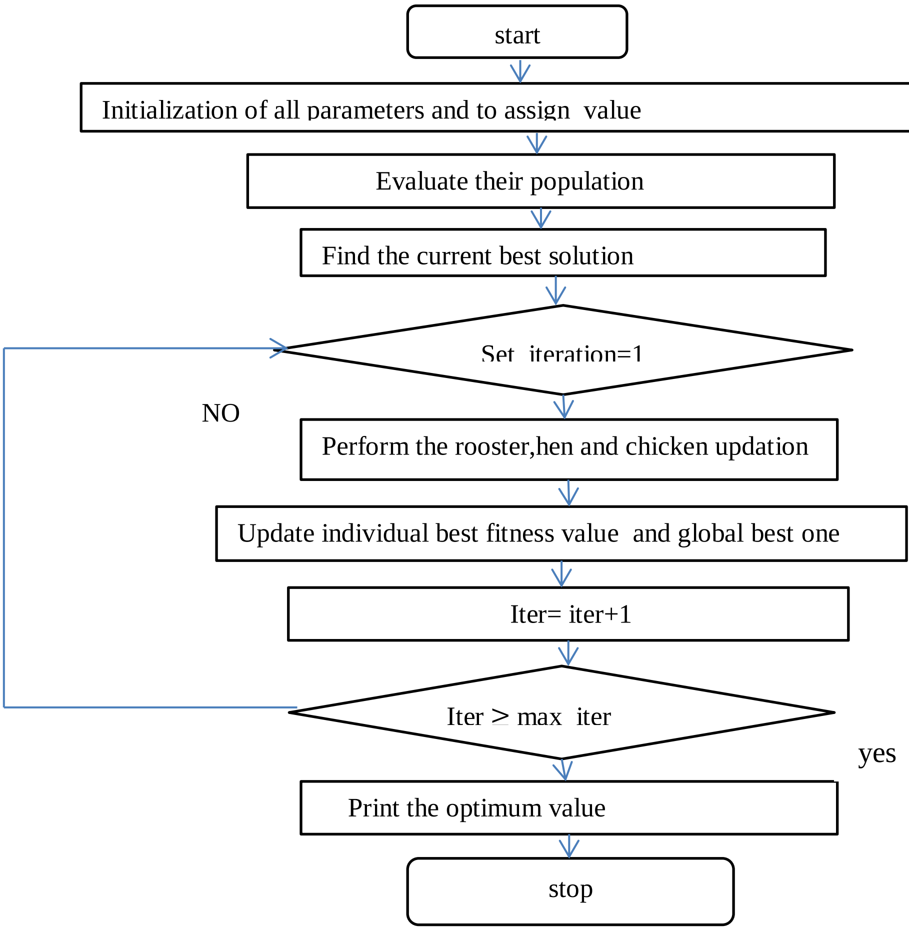
Chickens follow their group-mate rooster to search for food, while they may prevent the ones from eating their own food. Assume chickens would randomly steal the good food already found by others. The chicks search for food around their mother(hen). S1=exp$\frac{(f_i - f_{r1})}{(abs(fi)+\varepsilon)}$ (7)

The dominant individuals have advantage in competition for food.Assume *RN*, *HN*, *CN and MN* indicate the number of the roosters, the hens, the chicks and the mother hens, respectively. The best *RN* chickens would be assumed to be roosters, while the worst *CN* ones would be regarded as chicks.

$$s2= exp\left((f_{r2} - f_i)\right) \qquad (8)$$

step 3:update their best one. The rest are treated as hens. All *N* virtual chickens, depicted by their positions $x_{i,j}^{t}(i \in [1 \ldots N], j \in [1 \ldots N])$ at time step *t*, search for food in a *D*-dimensional space. In this work, the optimization problems are the minimal ones. Thus the best *RN* chickens correspond to the ones with *RN* minimal fitness values.

$$x_{i,j}^{t+1} = x_{i,j}^{t} + FL * \left(x_{m,j}^{t} - x_{i,j}^{t}\right) \qquad (9)$$



CSO ALGORITHM APPLIED TO EPD MINIMIZATION:

Step 1: Form an initial generation of NP chickens in a random manner respecting the limits of search space. Each chicken swarm is a vector of all control variables, i.e. [P_g]. There are 5 P_g‟sin the IEEE-6 unit system and hence a candidate is a vector of size 1X5.

Step 2: Calculate the best values of all chicken solution by running the NR load flow. The control variable values taken by different rooster are incorporated in the system data and load flow is run. The total generation cost of each chicken is calculated.

Step 3: Determine the best hens which has global best searching food mechanism fitness value using equation. The rooster ,hen and chicks are arranged in the ascending order their (sound echoes) and the first hen's will be the candidate with best food searching canditate (minimum cost)and give best global index value.

Step 4: Generate new rooster around the global best swarm by adding/subtracting a normal random number according to equation. It should be ensured that the control variables are within their limits otherwise adjustr ‟and α‟the.„ values of chicken swarm group.

Step 5: Hen , rooster ,chicks which one is given the best global fitness value until this process take place with number of iteration. Repeat steps 2-4 until stopping criteria has not been achieved.

IV. SIMULATION RESULTS AND DISCUSSIONS

4.1 TEST SYSTEM:

The efficiency of the CSO based method is tested on the system. The algorithm is coded in MATLAB 7.8 environment. A Core2Duo processor based PC is used for the simulations.IEEE-6 unit test system is a medium size test system and is widely used for many power system related research work. The system line data and bus data are taken from [1]. The dimension of this optimization problem rating cost. The system is considered under base load conditions and the p.u. data are on 100 MVA basis.

Table 4.1 Generator unit data (6-unit system)

Unit	**a_i (\$/hr/MW^2)**	**b_i (\$/hr/MW)**	**c_i (\$/hr)**	**P_i^{min} (MW)**	**P_i^{max} (MW)**	**P_i^0 (MW)**	**UR_i (MW/hr)**	**DR_i (MW/hr)**	**Prohibited zones**
1	0.0070	07.00	240	100	500	440	80	120	[210,240] [350,380]
2	0.0095	10.00	200	50	200	170	50	090	[90,110] [140,160]
3	0.0090	08.50	220	80	300	200	65	100	[150,170] [210,240]
4	0.0090	11.00	200	50	150	150	50	090	[80,90] [110,120]
5	0.0080	10.50	220	50	200	190	50	090	[90,110] [140,150]
6	0.0075	12.50	190	50	120	110	50	090	[75,85] [100,105]

In this case the basic form of cost function is taken. The cost co-efficient are shown in table A-1.CSO algorithm is run for fuel cost minimization as the objective. The real power settings shown in table 1 are found to be the best one for cost minimization. The fuel cost obtained is 15444.9\$/hr. It is lower than the cost reported in the recent literatures. The loss reduction is slightly more than the loss level achieved in but lowers than what is given in.

Methods	P1(MW)	P2(MW)	P3(MW)	P4(MW)	P5(MW)	P6(MW)	TOTAL COST(\$/h)
GA[3]	474.81	178.64	262.21	134.28	151.90	74.18	15459.0
PSO[3]	447.50	173.32	263.47	139.06	165.48	87.13	15450.0
CPSO[7]	434.43	173.32	274.47	128.06	179.48	85.93	15446.0
AIS[8]	458.29	168.05	262.52	139.06	178.39	69.34	15448.0
MTS[9]	449.37	182.25	254.29	143.45	161.97	86.02	15451.6
TSA	451.731	185.23	260.93	133.10	171.08	73.51	15449.2
BA	438.65	167.90	262.82	136.77	171.76	97.67	15445.9
PSO	444.24	170.83	254.68	141.32	173.04	91.36	15446.1
GA	438.42	178.99	270.88	131.59	166.55	89.20	15446.6
PSOM1	451.36	174.21	257.36	137.05	165.15	90.36	15444.6
PSOM2	444.72	172.37	260.50	144.86	167.15	85.23	15444.5
PSOM3	450.08	170.83	270.00	129.01	166.99	88.76	15444.9
PSOM4	447.77	178.19	256.46	134.75	171.63	86.80	15444.9
CSO	415.81	171.89	267.66	127.28	189.88	94.17	**15336.4**

Table 4.2 Optimal real power settings, fuel cost and loss (Case 1)

The above mention tabular column give the best results of chicken swarm algorithm ,when comparing to previous algorithm are reported in the literature.

Table 4.3 Comparison of the total generation fuel costs for case1

Cost	Algorithm		
	GA	PSO	CSO[12]
Best cost	15459.46	15450.4	15336.4
Average cost	16829.52	16134.40	1402.567
Worst cost	17345.58	17641.41	17641.43

4.1.1 CASE 1: QUADRATIC COST CURVE

CSO algorithm is run for fuel cost minimization as the objective. The real power settings shown in table 1 are found to be the best one for cost minimization. The fuel cost obtained is .15336.40$/hr.

The above mention tabular column give the best results of chicken swarm algorithm

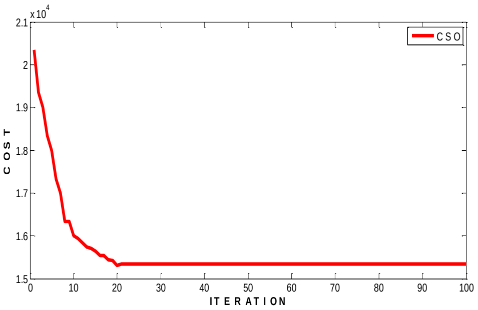


Figure 5.2 Convergence of CSO with quadratic cost curve

V. CONCLUSION In this work, a new bio inspired algorithm is implemented for the ELD problem. The numerical results clearly show that the proposed algorithm gives better results. The CSO optimization algorithm output performs the recently reported algorithms. The strength of the algorithm is proved with two different objective functions, both smooth and non -smooth functions, such as ramp-rate limits and prohibited zones. The algorithm with less number of operators and easy to be calculated in any computer language. Power system operation optimization problems can be attacked with this algorithm. Power system operators can use this algorithm for various optimization tasks.

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