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Application of Modified ALO to Economic Load Dispatch for Coal Fired Stations

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Abstract: ***This manuscript explores the novel Modified Ant Lion (MALO) Optimization to resolve the load dispatch problem optimally. The primary role of Optimal Economic Load Dispatch (OELD) is to obtain an efficient and economical operation of a power system network. The main aim of performing the OELD is for minimizing the fuel cost of the real power generation when the losses are neglected. An Modified Ant Lion (MALO) Optimization is a narrative nature-inspired algorithm and apes the tracking mechanism of ant lions in life. The random walk of ants, building traps, entrapment of ants in traps, catching preys, and re-building traps are the five main steps involved in the hunting process. The principal objective of OELD is to curtail the total generation cost while honoring effective constraints of accessible generating resources. The anticipated Modified ALO technique is utilized on three and six unit test system to various load demands for solving the load dispatch problem economically. A statistical result clarifies that the anticipated MALO method has lowest fuel cost and superior in quality of solution than other optimization techniques accounted in most latest literature.***

Index Terms: ***Modified Ant Lion Optimization, Economic Load Dispatch, Fuel Cost, Different Load Demands, Real Power Generation, Coal Fired Station, Without Losses.***

I. INTRODUCTION

Economic Dispatch forms the significant analysis roles dealing with Operation in a power transmission system. Economic Dispatch (ED) is defined as the route of distributing real power generation to the each generating unit, so that the total network load is supplied with most economical manner. In static economic dispatch, the point is to evaluate, the output power of all generating units so that all the loads are energized at minimum cost, while satisfying the various equal and inequality restrictions of the network and the generator limits. Economic Dispatch models the electric power system and dispatch the essential load from the accessible, well, generating units for each control area in the most economic manner or in real-time situation. The point is to reduce the total generation cost (include fuel cost, but exclude the cost of network loss) by meeting the operational constraints.In modern days, different evolutionary and meta-heuristics optimization techniques have been designed for simulating natural phenomena such as: Bat Algorithm (BA) [1], Particle Swarm (PSO) Optimization [2], Moth-Flame Optimization [3, 15], Cuckoo Search Algorithm (CSA) [4], FireFly Algorithm (FA) [5], Real Coded Genetic Algorithm (RCGA) [6], DragonFly Algorithm (DFA) [7], Grey Wolf Optimizer (GWO) [8], Evolution Optimization Swarm Algorithm (EOSA) [9], Sine Cosine algorithm (SCA) [10], Glowwarm Swarm Algorithm (WSA) [11], Hybrid Big Bang-Big Crunch Algorithm (HBBBCA) [12], Ant Lion Algorithm (ALO) [13, 17], Novel Bat Algorithm (NBA) [14], stochastic whale optimization (SWO) [16, 18], Moderate Random Search PSO (MRS-PSO) [19], Multi-Verse (MVO) Optimizer [20] and Sine Cosine Algorithm (SCA) [21]. Some of the heuristics evolutionary algorithms are used to resolve economic dispatch problems, which is reported in published literature as Bat Algorithm (BA), Cuckoo Search Algorithm (CSA) [4], FireFly Algorithm (FA) [5], Real Coded Genetic Algorithm (RCGA) [6], Evolution Optimization Swarm Algorithm (EOSA) [9], Glowwarm Swarm Algorithm (WSA) [11], Hybrid Big Bang-Big Crunch Algorithm (HBBBCA) [12], Ant Lion Algorithm (ALO) [17], Novel Bat Algorithm (NBA) [14], stochastic whale optimization (SWO) [18], Moderate Random Search PSO (MRS-PSO) [19].This manuscript recommends, Modified ALO algorithm is utilized for the elucidation of economic load dispatch to condense the cost of fuel in steam power station for different load demands. The projected Modified ALO has tested on simple 3-unit and 6-unit test systems.

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II. PROBLEM FORMULATION

A. Fitness Function

The aptness of the load dispatch hitch is to curtail the cost correlated to total generation while checking the limits of constrictions, when the essential power demand of a network is being supplied. The main objective of this task is to reduce cost given by the subsequent equation.

Minimize $F_T = F_i(P_{Gi}) = F_1(P_{G1}) + F_2(P_{G2}) + ------ + F_n(P_{Gn})$

$$F_i(P_{Gi}) = \sum_{i=1}^{n} F_i(P_{Gi}) \qquad ......(1)$$

$$F(P_G) = \sum_{i=1}^{n} \left(a_i P_{Gi}^2 + b_i P_{Gi} + c_i \right) \qquad ......(2)$$

B. Equality Restraint

The total generation of all generators should be meet the required load demand. The power balance equation without losses is given by

$$\sum_{i=1}^{n} P_{Gi} = P_D \qquad ......(3)$$

C. Inequality Restraint

The active power of all the generators in a coal fired station is to be inhibited within its functional limits.

$$P_{Gi}^{min} \le P_{Gi} \le P_{Gi}^{max} \quad i=1,2,.......n \qquad ......(4)$$

III. ANT LION OPTIMIZATION

A. Introduction

This article suggested a novel environment motivated algorithm called Ant Lion Optimization [13, 17] as a different practice to crack optimization problems. As the name signifies, Modified ALO algorithm emulates the sharp exploits of antlions in tracking ants in the atmosphere. The life series of AntLions is revealed in Fig. 1 and altered phases engaged while a corner and hunting the prey is publicized in Fig. 2 [13].

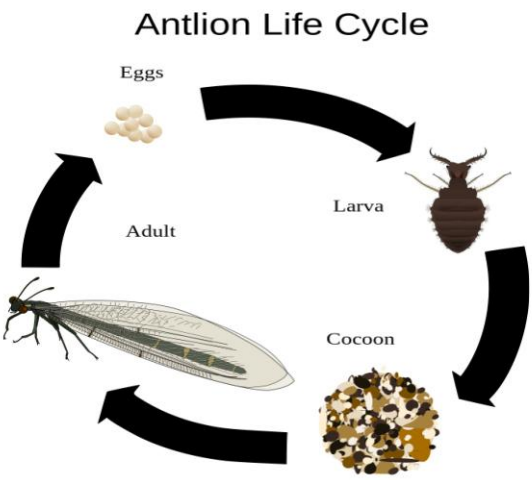

Fig. 1: Existence of an Ant Lions

The life cycle of antlions comprises two phases are of Larvae & Adult. A total lifespan can take up to 3 years, which mostly transpires in larvae. Antlions undergo metamorphosis in a cocoon to turn out to be an adult. Ants typically pursue in larvae and the parenthood era is for reproduction.

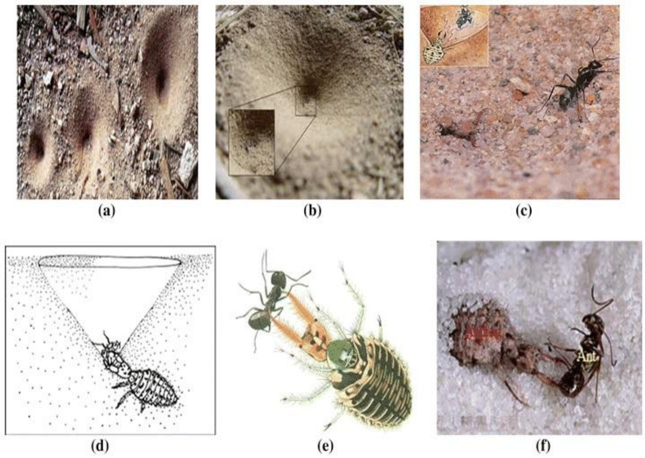

Fig. 2: a–c Erection Traps And Snare Of Ants In Ruses; D–F Contagious The Prey And Re-Building Traps

The ALO mimics relations involving ant-lions and ants in the trap. Since ants voyage stochastically in life when penetrating for groceries, a random walk using roulette wheel is preferred for the modelling ant movement.

The random walks within the search space are kept within boundaries, normalized using min–max normalization.

$$X = \left[0, CumSum\left(2*\left(rand\left(\max\_iter, 1 \right) > 0.5 \right) - 1 \right) \right]$$

$$RW(i) = X(i) = \frac{\left((X-a).*(d-c) \right)}{(b-a)} + c \qquad ......(5)$$

$$Where, \quad a = \min(Rand\_Walk)$$
$$b = \max(Rand\_Walk)$$
$$c = lb(dim)$$
$$d = ub(dim)$$

$$ant\_pos(i) = \left(ant\_pos(i).*\left(\sim \left(Flag4ub + Flag4lb \right) \right) \right) + ub.*Flag4ub + lb.*Flag4lb \qquad (6)$$

Pseudo Code
% Initialize input data, search agents and maximum iteration
% Initialize generator coeffecients, lower and upper limits each generator
% Initialize the positions ants
% Initially, evaluate the fitness
for $i = 1:n$
for $i = 1:dim$
$RandomWalk(i) = (d(i) - c(i)) * rand + c(i)$
Calculate $Ant\_Pos(i) = RA(i) + RE(i)/2$
end
end
% Boundar checking
% Update positions
% If any antlinons becomes fitter then Update elite position
% Update convergence criteria
display Best_score as Ant_Lion Fitness

B. Flow Chart for Optimal Economic Load Dispatch

The flow chart for Economic load dispatch problem by using Modified ALO algorithm is presented in Fig. 3. The ants travel stochastically in nature, while penetrating for food.

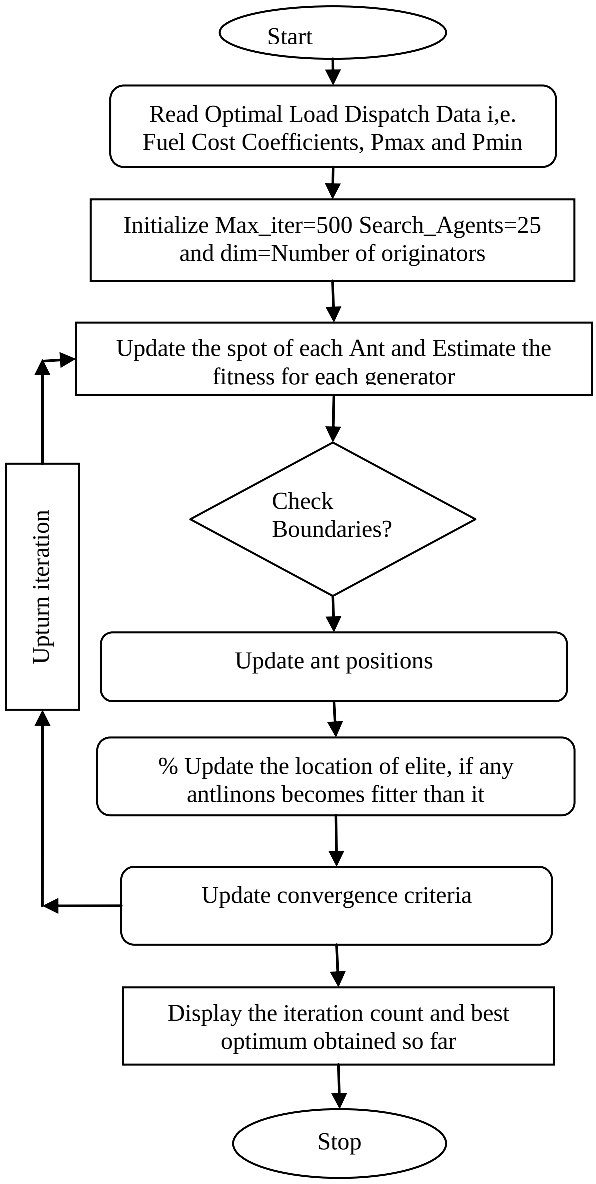

Fig. 3: Flow Chart For ELD Problem Using Modified Ant Lion Optimization

IV. UNITS

The Modified ALO is executed to decipher ELD problem with benchmark 3 and 6 thermal units. The MATLAB code tested on Version R2014a on an Intel, Core™ i3-3227U, CPU@ clock speed of 1.90 GHz, and 8GB RAM, 64-bit OS. The assessment results of the three and six unit systems are revealed. The capricious parameters of Modified ALO are offered in Table. 1.

TABLE I. ALO PARAMETERS

Organize Parameters		
1.	Search Agents	100
2.	Maximum Iterations	500
3.	Dimensions	3 (for 3-Gen system) 6 (for 6-Gen system)

A. Three-Unit System

The generator coefficients and lower, upper boundaries for each generator in a thermal system data are revealed in Table. 2. The planned Modified ALO is realized in the OELD problem when transmission losses are not included and end results of the fuel cost for altered load demands, i.e. 350, 400, 450, 500, 550, 600, 650, 700, 750 and 800 MW are offered in Table. 3.

TABLE II. GENERATOR COEFFICINTS AND INEQUALITY CONSTRAINTS OF 3-GENERATOR SYSTEM

Unit	a	b	c	Pmin	Pmax
1	0.03546	38.30553	1243.5311	35	210
2	0.02111	36.32782	1658.5696	130	325
3	0.01799	38.27041	1356.6592	125	315

TABLE III. OPTIMUM LOAD DISPATCH RESULTS OF 3-GENERATOR SYSTEM

Load Demand (MW)	P_1 (MW)	P_2 (MW)	P_3 (MW)	Fuel Cost (Rs./hr)
350	64.97302	155.9829	129.0441	18315.5651
400	75.7237	174.0416	150.2347	20480.2969
450	86.47439	192.1003	171.4253	22683.1507
500	97.22508	210.159	192.6159	24924.1263
550	107.9758	228.2177	213.8066	27203.2239
600	118.7264	246.2764	234.9972	29520.4433
650	129.4771	264.3351	256.1878	31875.7847
700	140.2278	282.3938	277.3784	34269.2481
750	150.9785	300.4525	298.569	36700.8333
800	163.5053	321.4947	315	39171.2478

B. Six-Unit System

The 6-unit test system generator coefficients, min and maximum limits for real power generation of data are exposed in the Table. 4.

TABLE IV. GENERATOR COEFFICINTS AND INEQUALITY CONSTRAINTS OF 6-GENERATOR SYSTEM

Unit	a	b	c	Pmin	Pmax

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1	0.15240	38.53973	756.79886	10	125
2	0.10587	46.15916	451.32513	10	150
3	0.02803	40.39655	1049.9977	35	225
4	0.03546	38.30553	1243.5311	35	210
5	0.02111	36.32782	1658.5596	130	325
6	0.01799	38.27041	1356.6592	125	315

The planned Modified ALO is realized and the outcomes of the fuel cost for various load demands, i.e. 600, 700 and 800 MW are offered in Table. 5.

TABLE V. OPTIMUM LOAD DISPATCH RESULTS OF 6-GENERATOR SYSTEM

Load Demand (MW)	600	700	800
P1	21.1895	24.97371	28.7579
P2	10	10	10
P3	82.0860	102.6604	123.2360
P4	94.3706	110.6347	126.8982
P5	205.3642	232.6838	260.0032
P6	186.9897	219.0473	251.1047
Cost(Rs./hr)	31445.6229	36003.1239	40675.968

C. Comparison of Six-Unit Test System Results

The test results of 6-unit system are compared with the other meta-heuristic optimization techniques which are previously published articles in the literature under the same operating conditions and presented in Table. 6.

TABLE VI. COMPARATIVE OUTCOMES OF 6-UNIT SYSTEM

Power Demand	FFA [5]	MFA [5]	VSMFA [5]	MFF A [5]	Proposed MALO
600	31489	31447	31576	31481	31446
700	36075	36006	36036	36021	36003
800	40739	40676	40701	40740	40676

From the above comparison, detect that Modified ALO attain the least amount of fuel cost for different power demands as evaluated when the losses are neglected. The convergence criteria is also improved by modified ALO.

The graphical representation of comparative results for 600MW, 700MW and 800MWare exposed in Fig. 3, Fig. 4 and Fig. 5 correspondingly.

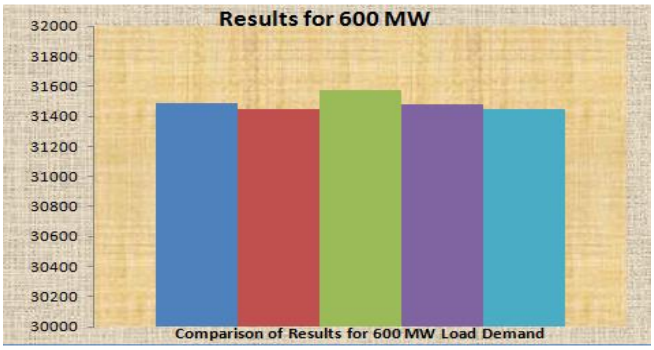

Fig. 4: Graphical Representation For Load Demand 600 MW

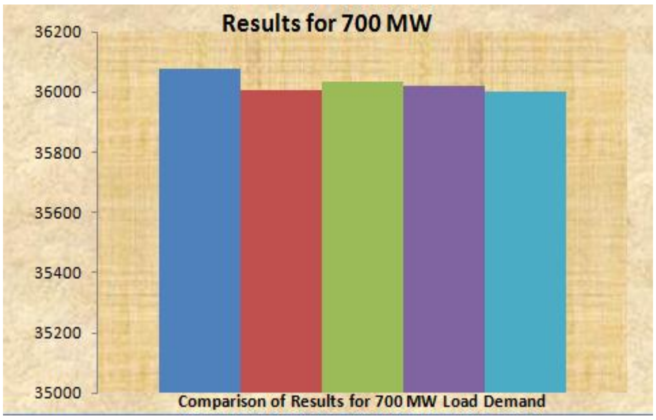

Fig. 5: Graphical Representation For Load Demand 700 Mw

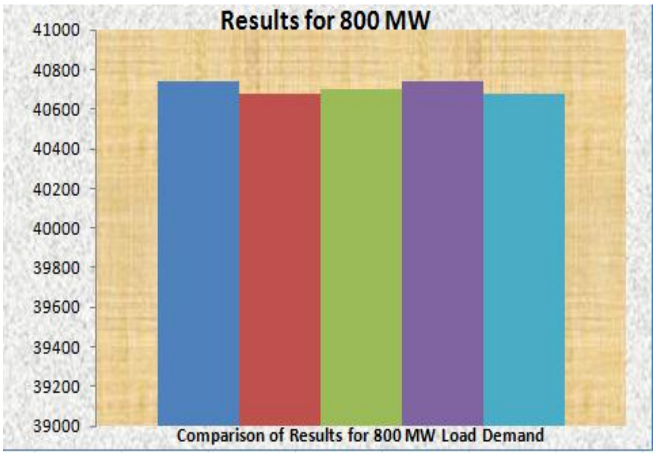

Fig. 6: Graphical Representation Load Demand For 800 MW

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