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AN OPTIMISTIC SOLUTION TECHNIQUE FOR ECONOMIC LOAD DISPATCH PROBLEM USING IMMUNE INSPIRED ALGORITHM

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ABSTRACT: Scarcity of Energy resources, increasing power generation cost and ever-growing demand of electric energy necessitates optimal economic dispatch in today's power systems.In this paper presents a computational approach to minimize the total fuel cost in thermal power station using Artificial Immune System (AIS) algorithm. The AIS algorithm is a machine learning approach and a powerful stochastic optimization technique with special features of random search, hill climbing, statistical sampling and competition. The proposed test system consists of six generator units. The analytical computation and simulation of above test system has been performed using the MATLAB environment. The performance analysis of proposed approach is compared with conventional and other optimization algorithms.

Keywords- Economic Load Dispatch (ELD), Artificial Immune System (AIS) Algorithm, Genetic algorithm (GA).

I. INTRODUCTION

The basic objective of economic dispatch of electric power generation is to schedule the committed generating unit outputs so as to meet the load demand at minimum operating cost while satisfying all unit and system equality and inequality constraints. The economic dispatch problem is very complex to solve because of its colossal dimension, a non-linear objective function, and a large number of constraints. The various mathematical programming methods such as Lambda iteration method, participation factors method and gradient methods. Well known long-established techniques such as integer programming [1], [2], dynamic programming [3],[4], and Lagrangian relaxation [5] have been used to solve the economic dispatch problem. Recently other optimization methods such as Simulated Annealing [6], Hopfield Neural Network [7], [8], Genetic Algorithm [9], Particle Swarm Optimization [10] and Tabu Search Algorithm [11] are practiced to solve the economic dispatch problem.

In this paper, a novel implementation of the AIS algorithm is based on pattern recognition and anomaly detection proposed to solve the economic dispatch problems. The effectiveness of proposed algorithm is demonstrated using IEEE 30 bus six generator system considering emission constraints. The implementation of the above algorithm is organized as follows. In section 2, a mathematical formulation of the economic dispatch problem. In section 3, an overview of proposed method using AIS algorithm and their characteristics. In section 4 gives a description of test system. In section 5 includes the simulation results and discussion and conclusions in section 6.

II. PROBLEM FORMULATION

The objective of solving economic dispatch problem is to minimize the fuel cost of electric power system, while satisfying a set of constraints. This can be formulated as follows:

a) Problem objective

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Minimization of fuel cost: The objective function for the total (Rs/hr) fuel cost can be expressed as

$$F(P) = \sum_{i=1}^{n} F_i(P_i) \qquad (1)$$

The fuel cost equation of a generating unit is usually described by a quadratic function of power output P_i as follows:

$$F_i(P_i) = \sum_{i=1}^{n} (a_i P_i^2 + biP_i + c_i) \frac{Rs}{hr} \qquad (2)$$

Where, F_i (P_i) is the fuel cost (Rs/hr), P_i is the power generated (MW) and a_i, b_i, $c_i$is the fuel cost coefficients ofith unit.

b) Problem constraints

Generation capacity constraint: For stable operation, real power output of each generator is restricted by lower and upper limits as follows

$$P_i^{min} \leq P_i \leq P_i^{max}, \ i=1, 2\ldots n \qquad (3)$$

Power balance constraint: The total power generation must cover the total demand P_D and the real power loss in transmission lines P_L. Hence,

$$\sum_{i=1}^{n} P_i = P_D + P_L \ \text{MW} \qquad (4)$$

c) Problem Statement

Aggregating the objective and constraints, the problem can be mathematically formulated as a nonlinear emission constrained single objective optimization problem as follows

Minimize	: [F (P)]	(5)
Subject to	: g (P) =0	(6)
	h (P)≤ 0	(7)

Where g is the equality constraint representing the power balance and h is the inequality constraint representing the unit generation capacity.

III. PROPOSED APPROACH

Recently the proposed AIS algorithm can be effectively used to reduce the fuel cost in thermal power station.The AIS can be defined as a computational system based upon metaphors of the biological immune system.

a) Artificial Immune System Algorithm

The immune system is a meta-synthesis process that uses the information contained in the problem itself to define the solution tool to a given problem, and then apply it to obtain the problem solution. The topicsinvolved in the definition and development of the artificial immune systems cover mainly:

a) Hybrid structures and algorithms that take into account immune-like mechanisms.

b) Computational algorithms based on immunological principles, like distributed processing, clonal selection algorithms, and immune network theory.

c) Immunity-based optimization, learning, self-organization, artificial life, cognitive models, multi-agent systems, design and scheduling, pattern recognition and anomaly detection.

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d) Immune engineering tools. Potential applications of the artificial immune systems can be listed (but are not limited to): Pattern recognition, function approximation and optimization, anomaly detection, computerand network security, generation of diversity and noise tolerance.

IV. IMPLEMENTATION OF THE PROPOSED ALGORITHM

The step by step procedure of AIS for the optimization of generation cost can be outlined as follows:

Step1: Read the data, namely cost coefficients, a_i, b_i, c_i,P_i^{min}&$P_i^{max}$of all generating units and population size etc.

Step2:Generate an array of random binary string value.

Step3: Decode the string to actual value.

Step4: Insert them in population pool.

Step5: Check the satisfaction of constraints of the objective function if 'yes' go to (6) else go to (1).

Step6: Evaluate fitness of each set of generation to meet out the demand using the formulae

$$\text{Fitness (F')} = \frac{1}{(1 + \alpha\, (\acute{\varepsilon} / P_D))}$$

Where,

$$\acute{\varepsilon} = P_D + P_L - \sum_{i=1}^{n} P_i$$

n = number of generators.

Step7: Select the antigen and antibody from the fitness values

Step8: Calculate the Euclidean distance between antibody and antigen using

$$D_{ij} = \sqrt{\sum_{k=1}^{n} (x_{i,k} - x_{j,k})^2}$$

Step9: If D_{ij} is more select them for hyper mutation else simple mutation by cloning theantibody.

Step10: Enter the cloned population in new population pool.

Step11:Verify the satisfaction of constraints for the objective function.

Step12: Check the convergence else go to clonal proliferation.

V. TEST SYSTEM

The Economic Load Dispatch problem based on Artificial Immune System (AIS) algorithm has applied to the six generator test system. Multiple generator limits and total generation cost of the system is simulated in order to evaluate the correctness and quality of the method.The fuel cost constants and the generator limits of a six generator system are tabulated below,

Table.1 Input Data for fuel cost coefficients

Unit	Fuel Cost Coefficients			P_i (min) MW	P_i (max) MW
	a_i	b_i	c_i		
P1	0.0000	2.0000	0.0037	50	200
P2	0.0000	1.7500	0.0175	20	80
P3	0.0000	1.0000	0.0625	15	50
P4	0.0000	3.2500	0.0083	10	35
P5	0.0000	3.0000	0.0250	10	30
P6	0.0000	3.0000	0.0250	12	40

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Table.2 Transmission Loss coefficients

Transmission Loss Coefficients						
B_{ij}	1	2	3	4	5	6
1	0.000218	0.000102	0.000010	0.000010	0.000001	0.000027
2	0.000102	0.000187	0.000004	0.000015	0.000003	0.000031
3	0.000010	0.000004	0.000430	0.000134	0.000160	0.000108
4	0.000010	0.000015	0.000134	0.000097	0.000097	0.000051
5	0.000001	0.000003	0.000160	0.000256	0.000256	0.000000
6	0.000027	0.000031	0.000108	0.000000	0.000000	0.000359

VI. SIMULATION RESULTS AND DISCUSSIONS

In this paper, the Artificial Immune System algorithm was tested on the standardtest system with six generators for the load demand of 350 MW. Table.3 show that the comparisons of the performance of the AIS algorithm with the Genetic algorithm.

Table.3 Optimized Fuel cost of 6 generator system.

Unit	Power Demand (P_D) = 350 MW		
	Proposed (AIS) method	GA	Conventional method
P1	195.864	200.000	209.8791
P2	40.536	80.000	59.2657
P3	15.000	21.243	22.6777
P4	10.000	18.193	38.0782
P5	10.000	15.568	17.5182
P6	12.000	17.992	17.2509
Total fuel cost (Rs/hr)	1014.660	1017.663	1057.95

Fig.1 show that the graph contains the total fuel cost (Rs/hr) on the Y-axis and Load demand (MW) on the X-axis.

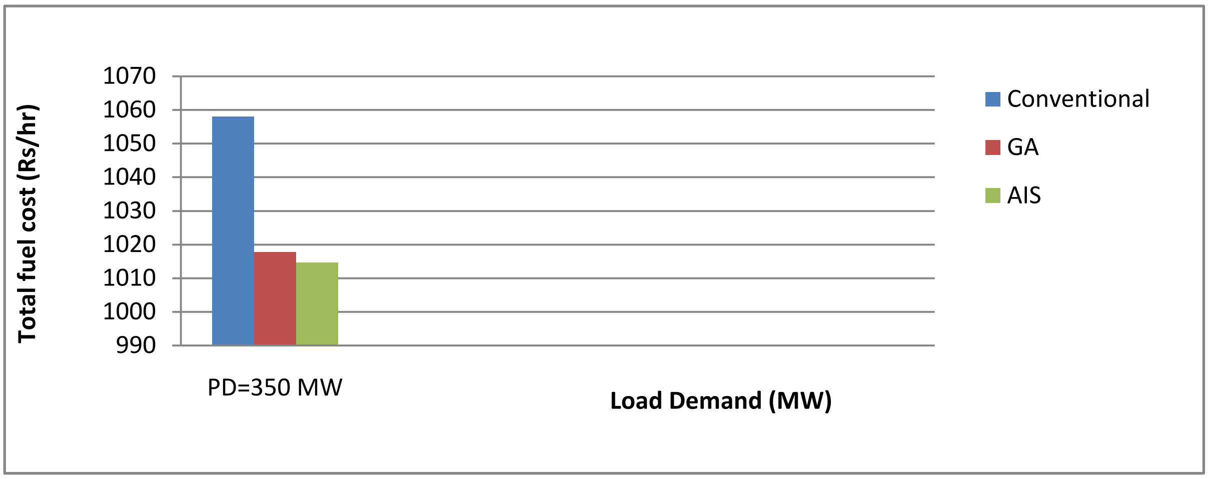

Fig.1 Fuel-cost curve

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VII. CONCLUSION

Economic Load Dispatch problem being attempted using AIS algorithm for six generator test system evaluates the performance of the proposed approach. The solution is analytic in nature with high accuracy and fast computational time. Therefore, this results shows that AIS optimization is a promising technique for solving complicated problems in power system.

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BIOGRAPHY

S.Palaniyappan obtained Diploma in Electrical and Electronics Engineering in the year 2006 and got District first from MIET Polytechnic College and his Bachelor degree in Electrical & Electronics Engineering from A.C.College of

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