Particle Swarm Intelligence based dynamics economic dispatch with daily load patterns including value point effect

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ABSTRACT:- Economic load dispatch provides optimization method which divides demand of the power among online generators economically by satisfying different constraints. ELD can concluded as scheduling of committed generating units by meeting up the demands of the consumers while reducing operational cost to the utilities with satisfying equality and inequality constraints.

In this work several ELD optimization algorithm have analyzed such as APSO, PSO, HS, DE and SA. These optimization algorithms can be used as per the requirement of the system. A hybrid mechanism i.e. Firefly-ST (Firefly Optimization-State Transition) algorithm for ELD is developed in this study. Resultant graph in the result and discussion section shows that proposed work is better in terms of load demand and total generation cost in comparison to the PSO, SA, DE, HS and APSO.

Keywords— *Economic Load Dispatch, Firefly, State Transition, Power Generation, Load demand, Total cost.*

I. INTRODUCTION

The economic dispatch problems of electrical power generation aim to manage the output of committed generating units in order to satisfy the load demand at minimum incurred cost at the same time as to fulfill the all the constraints whether it is equality constraint or inequality constraint [1]. The issue of Economic Load Dispatch is need to be resolved by specific computer software that should be capable to works on operational and system constraints with respect to the available resources and relative power transmission capabilities [2].

Major requirement of ELD is to distribute the power among different units so that the load demand of all the units can be fulfilled. In addition to this it is also required to reduce the cost incurred by fuel and power transmission [3]. In this process the load is distributed in such a way that power system utilized in efficient manner and also fulfills the consumer demand in optimum way [4]. Main problem associated with the electric power generation is to schedule the output power units generated in order to fulfill the user's demand of electric power with minimum cost for operation [5].

The power generators corresponding output energy is established by considering ELD as a optimization problem. The system operations cost gets reduced by it that can be formulated as given below:

Minimize $f(x)$, the objective function

Subject to $g(x)$ and $h(x) \leq 0$, set of equality and inequality constraints.

The ELD optimization plays a vital role in the reduction of the total operating cost of the power generator system. It is done by tuning the output of power generators which is linked to the grid by fulfilling the total load requirements and transmission losses within range of the power generators. The curve of the power generator cost is modeled by using a quadratic function which is subjected to equality and inequality parametric constraints which is defined below:

$$F_i p_i = \sum_{i=1}^{n_g} (y_i P_i^2 + \beta_i P_i + \alpha_i) \dots\dots (1)$$

$F_i p_i$, total generating cost

n_g, dispatchable generator nodes

y_i, β_i, α_i, cost coefficients

Subjected to power balance equation of equality constraint:

$$\sum_{i=1}^{n_g} P_i = P_D + P_l \dots\dots\dots (2)$$

P_D, Load demand

P_i, Real power generator

Power flow equation can be utilized for determining the system losses. This is done on the basis of the krons loss formulae.

$$P_l = \sum_{i=1}^{n_g} \sum_{j=1}^{n_g} P_i B_{ij} P_j + \sum_{i=1}^{n_g} B_{0i} P_i + B_{00} \dots\dots (3)$$

P_l, power transmission loss

For inequality constraint

$$P_{i(min)} \leq P_i \leq P_{i(max)} \dots\dots\dots (4)$$

$P_{i(min)}$, minimum power generation limit

$P_{i(max)}$, maximum power generation limit

II. PROBLEM FORMULATION

The restructuring in electrical power industry has generated vivacious and competitive market which leads to the modifications in different aspects of the electrical industry. Economic Load Dispatch is considered as the significant optimization problem that is still a questionable issue and need to resolve. In ELD the demand of power is divided among the employed generators equally to balance the power load economically by fulfilling the rest of the constraints. ELD is the part of optimal power flow problem. In other words, the ELD is defined as the process of dividing the specific power generation units to the different generators so that the load power generation gets equally balanced and the cost of power generation gets reduced. A large number of researches has been conducted till now to resolve the issue optimization of ELD in power generation system. Recently, it has been seen that the global optimization techniques are deployed to resolve the issue of load dispatch. Such global optimization techniques are swarm intelligence based techniques and evolutionary algorithms etc. These algorithms have been proved as an optimal solution but also suffer from some issues. Thus, there is a need to update the solution.

III. PROPOSED WORK

The ELD has become the most prominent topic for research work. Traditionally, the optimization techniques such as Particle Swarm Optimization, Genetic Algorithm, Ant Colony Optimization firefly optimization etc were applied to optimize the economic load dispatch. Out of these optimization techniques, the firefly is found to have better results correspondingly. Thus, this study develops a ELD optimization technique by using firefly optimization technique and the state transition approach is also employed to enhance the performance capability of firefly approach. The reason behind hybridizing these optimization approaches is there superlative features than other optimization approaches. Firefly approach has the following benefits:

1) Its automatically subdivision ability
2) Its ability of dealing with multimodality.

Firefly is based on attraction and attractiveness decreases with distance. This leads to the fact that the whole population can automatically subdivide into subgroups, and each group can swarm around each mode or local optimum. The proposed technique uses the hybrid approach in order to minimize the cost incurred on power generating and transmission. The hybridization is done by using the firefly and state transition approach.

Firefly Approach

The concept of Firefly paradigm is introduced by the author Yang. Firefly is an insect who generates the small and rhythmic flashes which is generated by the procedure of bioluminescence. The partners or the potential prey is attracted by the operation of the flashing light and to the predator as a protective. Therefore, the fireflies move towards another fire flies by the factor of the intensity of light. From the eyes of the beholder the intensity of the light fluctuates at the distance. If the distance is maximized so the intensity of the light is minimized. The surroundings are absorbed by the control of the air; therefore intensity turns into less attractive if the distance is maximized. The three principle rules offered by the firefly paradigm are:

1) Despite of the gender the fireflies are fascinated towards one another.

2) The brightness of the fire flies is correlative to the attractiveness of the fireflies; therefore the minimum fascinated firefly will shift ahead to the extra fascinated firefly.

3) On the basis of the objective of the function the brightness of fireflies is occurred.

Objective Function f(x), x= $(x_{1,} \dots \dots \dots x_d)^T$

Genetic initial population of fireflies $x_i\ (i = 1,2, \dots., n)$

Light Intensity I_i $at\ x_i\ is\ determined\ by\ f(x_i)$

Define light absorption coefficient γ

While (t < Max Generation)

for i = 1:n all n fireflies

for j = 1: all n fire flies (inner loop)

if (I_i < I_j) Move firefly i towards j: **end** if

Vary attractiveness with distance r via exp [-γr]

Calculate novel resolutions and update light intensity

end for j

end for i

Rank the fireflies and find the present global best g.

end while

Therefore attractiveness is inversely proportional among the specific distance r from the light source in the light intensity. So the distance is maximized as the light and attractiveness is minimized.

$$I(r) = I_Q e^{-\gamma r^2} \quad .....(5)$$

I	=	Light intensity
I_Q	=	Light intensity at initial or original light intensity,
γ	=	The distance absorption coefficient

r	=	Distance between firefly i and j

Through the other fireflies it is seen that the attractiveness is proportional to the light intensity as the attractiveness is β

$$\beta = \beta_D e^{-\gamma r^2} \ldots. (6)$$

β_D	=	Attractiveness at r is 0

With the help of the Cartesian distance the distance within a couple of fireflies can described using Cartesian distance

$$r_{ij} = |x_i - x_j| = \sqrt{\sum_{K=1}^{d} 1\left(x_{i,k} - x_{j,k}\right)^2} \ldots\ldots(7)$$

Firefly i is fascinated to the extra fascinated firefly j, the movement is described as

$$\Delta x_i = \beta_0 e^{-\gamma r_{ij}^2}(x_j^t - x_i^t) + \alpha \epsilon_i, \qquad x_i^{t+1} + \Delta x_i \ldots\ldots (8)$$

In this equation number 8 the initial term is for attraction. When the significance is lean to zero or very big so the γ is the drawback. The attractiveness and brightness become steady $\beta = \beta_D$, when the γ approaching zero ($\gamma \rightarrow 0$). On the other hand, at any location a firefly can be noticed, simply to accomplish global research. As γ is approaching ∞ or very huge ($\gamma \rightarrow \infty$), so the attractiveness and the brightness is minimized. The movements of firefly are turned into random. In the couple of asymptotic behaviors the execution of the firefly paradigm is completed. So the second lean is for randomization as α the randomize parameter. The τ_i is swapped by ran -1/2 that is ran as random number created from 0 to 1.

State Transition Approach

State transition is a proficient mechanism that is considered as a suitable approach for decision making. It is extensively applicable to the pronouncement analytical modeling sphere of influence. It is created by collaborating the Markov model cohort simulation and stand alone simulation model. This mechanism reflects the states and corresponding transitions respectively. It is broadly accepted by the users in the field of clinical decision analysis, medical domain, industrial decision making etc. It is less complex and easy to use. Its major objective is to evaluate or detect the hidden risk factor, screening of the system, procedure diagnosing procedures, program management etc. This model is in essence used for expounding the time dependent systems specifically. The major characteristic of state transition is that its working criteria did not get affected by the variations in the surrounding environment. State transition is the only term that used in this method. In this state is defined as an observed behavior and nature of the system and transition manipulates the internal happening of the system. Transition event depicts the action which is taken with respect to any event.

The methodology of propose technique is as follows:

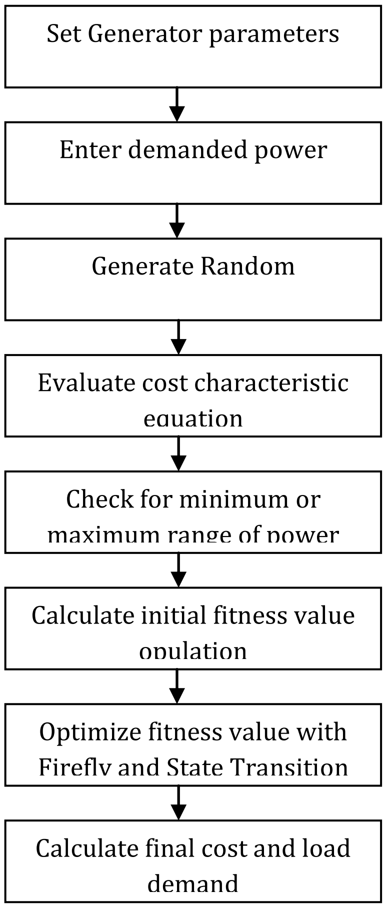

Figure 1 Block Diagram of propose work

First step is to set power generator parameters. Every generator has its own parameters such amount of generated power, amount of total lost transmission etc. The parameters are generated on the basis of some equations.

After setting the power generator parameters the power requirement or demanded power of various units will be entered. Now generate initial population. Now calculate the cost incurred on generating the power by using cost characteristic equation. Now evaluate the minimum or maximum range of generated power from the above calculated cost.

Number of iterations will execute in order to find the best fitness value. Now apply proposed hybrid mechanism for optimizing the fitness value from obtained set of fitness value. Evaluate the final output and various parameters such as total generated power. Total power loss, total cost incurred.

IV. RESULTS

This section provides a overview to the results that are obtained after implementing the proposed work i.e.

Hybridization of Firefly and ST optimization for ELD. The graph in figure 2 defines the cost function of propose work. The x axis in the graph shows the number of iterations considered in proposed work i.e. from 0 to 100. The graph defines that initially the cost function is quite higher when the number of iterations are 0. But the cost function starts falling gradually with the increment in the number of iterations. The lowest cost function is found at the 100th iteration in propose work.

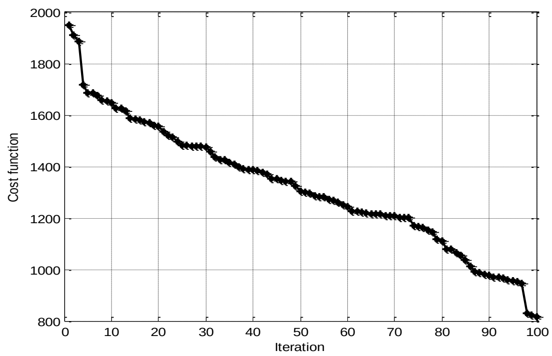

Figure 2 Cost Function Evaluation in propose work

The overall cost of the power system is evaluated with respect to the times in hours. In graph of figure 3 the tine in hours is calibrated by the x axis and the cost is calibrated by y axis. The value of hours ranges from 0 to 25 hours and the cost is started from 1100 and ends at 1800. For an ideal plant or power system, it is mandatory to have lowest cost with higher time in hours. As per the observations from the graph, it is observed that the lowest cost is observed at the 0 hrs of working and then the cost increases rapidly with the increment in the hours but after 10 hours, the cost started falling and at the end when the working hours reaches to the 25 hours then the evaluated cost is nearby 1200 dollars

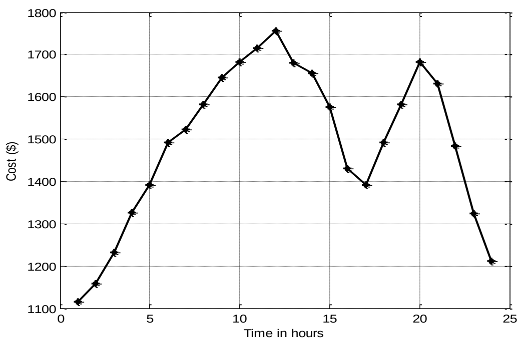

Figure 3 Cost v/s Time in hours of propose work

The graph in figure 4 is driven with an aim to evaluate the load demand in MW. This is evaluated with respect to the working time in hours. The load demand at the lowest time is measured to be 400 MW and the highest load demand is approximately 720 MW3.

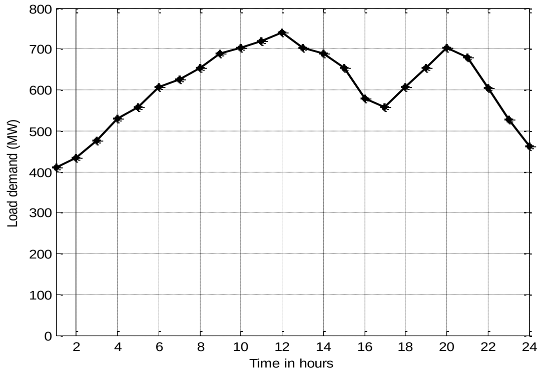

Figure 4 Load Demand evaluation of propose work

The comparison graph in figure 5 shows the comparison of traditional SA [15], APSO [16], DE [17], HS [18], PSO [19] and propose wok. The comparison is done in the terms of minimum total cost. The x axis in the graph depicts the various techniques that are considered for the comparison analysis and the y axis shows the values for minimum total cost.

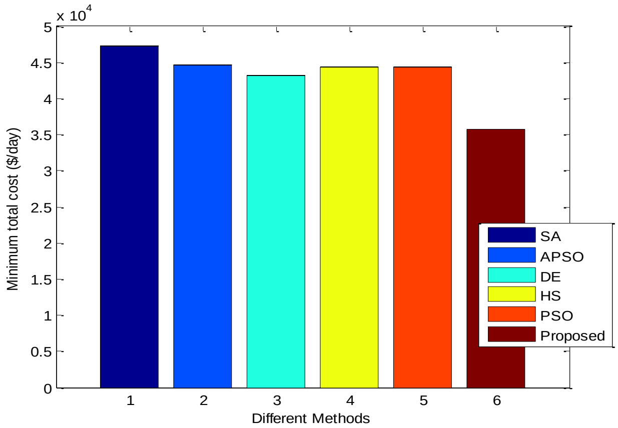

Figure 5 Minimum Total Cost Analysis

The graph proves that the traditional SA technique has the highest total cost then the APSO, DE, HS, PSO and proposed work. The plant with the lowest minimum total cost on daily basis is considered as an ideal power plant.

V. CONCLUSIONS

Economic Load Dispatch is the process known for distributing load in such a way so that economic cost of the power system should be used less and requirement of the consumer fulfilled. Thus in this work different optimization algorithms have been studied which can be used to evaluate proper distribution of load over the power systems. Evaluation has been done between PSO, APSO, SA, DE, HS and proposed hybrid Firefly-ST which ensures that BPSO-ST proposed work outperforms among them. Several parameters such as total generation cost and total load demand have been discussed. These parameters conclude that Firefly-ST is efficient, effective and optimized than other optimization technique. As various optimization algorithms have been evaluated in this work where Firefly-ST declares as an efficient technique.

In future, more amendments can be done by increasing the number of generators in the power plant. Along with this, more advanced optimization techniques can also be applied to increase the quality of the system.

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