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ECONOMIC LOAD DISPATCH PROBLEM OF POWER PLANT IN THERMAL ELECTRIC GENERATION SYSTEM USING SWARM OPTIMIZATION TECHNIQUE

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ABSTRACT

Economic Load Dispatch is basic research challenges and critical advancement work in the everyday operational arranging of age framework. It is here and now determination of the most ideal yield of various generators units, to meet the power framework stack, at the base conceivable cost, topic to operational requirements and transmissions. This research paper tries to show the numerical detailing of Economic load dispatch issue arrangement utilizing delicate registering method in electric era structure considering different physical and power induced system imperatives.

Keywords: *Economic Load Dispatch problem (ELDP), Basic mathematical formulation, Swarm Optimization.*

I. INTRODUCTION

In the current electric power frameworks, there are distinctive creating units e.g. hydro, steam, and biomass and so on. Likewise, the heap request vacillates for the time of a day and achieves diverse pinnacle esteems. In this way, it is basic to settle on which producing unit to off/on and furthermore the request in which the units must be closed down remembering the cost benefit of turning on and stopping. The entire work of figure and making these evaluations is known as load dispatch. The financial load dispatch implies that the generator's yield is permitted to change inside persuaded restrains so that to take care of a specific load demand contained by least fuel cost.

II. MATERIALS AND METHODS

A. Economic load Dispatch

Monetary Load Dispatch issue is vital in electric power framework activity and control. The principle target of the Monetary Load Dispatch issues is to make the best plan of energy yields of all creating units in order to gather the required request at least working expense while fulfilling the balance and imbalance constraints. Typically, the cost work for every unit in Financial Load Dispatch issues has been around characterized by a quadratic capacity and is settled utilizing Matlab programming procedures planning of the units together Monetary load dispatch.

B. Problem Formulation

In electric generation system, load dispatch problem is a constrained optimization problem and it can be expressed as Follows.[1-4]

Objective function to Minimize fuel cost (F),

$$F(P_i) = \sum_{i=1}^{NG} (a_i P_i^2 + b_i P_i + c_i) \quad \$/h \qquad (1)$$

Where, a_i (Rs/MW^{2}h), b_i (Rs/MWh) and c_i (Rs/h) are consumption coefficients of ith unit. Subject to
(i) The energy balance equation

Subheading should be 10pt Times new Roman, justified.
$NG \sum P_i = P_D + P_L$

$i=1$

(ii) The inequality constraints

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

Where a_i, b_i, c_i are fuel cost coefficients

P_D is Load Demand.

P_L is power transmission Loss.

NG is the number of generation buses.

P_i is real power generation and will act as decision variable.

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The very simple and fairly accurate method of expressing power transmission loss, P_L as a function of generator powers is through George's Formula using B-coefficients and mathematically can be expressed as:

$$P_L = \sum_{i=1}^{NG}\sum_{j=1}^{NG} P_{gi} B_{ij} P_{gj} \quad \text{MW}$$

where, P_{gi} and P_{gj} are the real power of generations at the i^th^ and j^th^ buses, respectively. B_{ij} are the loss coefficients.

C Thermal constraints

In this framework thermal generation of units needs to experience progressive temperature fluctuate and in this way it requires some time of investment to convey a unit on the web. Likewise, thermal generation unit can be physically controlled. So a team part is required to play out this errand in activity. This prompts great deals of confinements in the power framework activity of thermal generation and along these lines it give ascend to numerous requirements.

D. Generation Constraints

In order to convince the forecasted in power system load demand, the sum of all generating units on-line must equal the power system load over the time horizon

$$\sum_{i=1}^{NG} P_{ih} U_{ih} = D_h$$

Where, D_h is load demand at h^th^hour.,P_{ih} is the power output of ith unit at hth hour and U_{ih} is the On/Off status of the ith unit at the hth hour.NG is the number of thermal generating units

E. Unit Generation restrictions

The power output generated by the individual units must be within max. and min. generation limits i.e.

$$P_{i\,(\min)} \leq P_{ih} \leq P_{i(\max)}$$

Where, $P_{i(\min)}$ and $P_{i(\max)}$ is the minimum and maximum power output of the ith unit

F. Particle Swarm optimization

Particle Swarm Optimization (PSO) is a swarm-based intelligence algorithm influenced by the social behaviour of animals such as a flock of birds finding a food source or a school of fish protecting them from a predator. This soft computing technique first described by James Kennedy and Russell C. Eberhart in 1995 derives from two separate

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concepts ,the idea of swarm intelligence based off the surveillance of swarming habits by certain kinds of animals(such as fish & birds) and field of evolutionary computation.

A particle in PSO is analogous to a bird or fish flying through a search (problem) space. The movement of each particle is co-ordinate by a velocity which has both magnitude and direction. Each particle position at any instance of time is influenced by its best position and the position of the best particle in a problem space. The performance of a particle is measured by a fitness value, which is problem specific.

G. Mathematics formulation

The swarm enhancement calculation works by independently keeping up various competitor arrangements in the hunt space. For the (Pij) is time of every emphasis of the calculation, each competitor arrangement is computed by the target work being advanced, deciding wellness of that arrangement. Each contender arrangement can be thought of as particle ‘flying’ through the wellness scene finding the maximum or on the other hand minimum of the goal work toward the begin, the PSO calculation picks hopeful arrangements arbitrarily inside the pursuit space

$$V_i^{new} = w * V_{ij} + C_1 R_1 \left(Pb^{best}{}_{ij} - P_{ij}\right) + C_2 R_2 \left(G^{best}{}_j - P_{ij}\right) \; (i = 1, 2 \ldots NP; j = 1, 2 \ldots NG) \tag{4}$$

$$P^{new} = P_{ij} + V^{new} \tag{5}$$

P is the current position of j^{th}member of i^{th} particle at u^{th} iteration
$C1$, $C2$are the acceleration constants
$w$is the weighing function or inertia weight factor NP is the number of particles in a group
NG is the number of members in a particle $R1$, $R2$is random number between 0 and 1

Initial state of a four -particle PSO algorithm seeking the global maximum in a one-dimensional search space. The search space is composed of all the possible solutions along with objective function. It should be well-known that the PSO algorithm has no information of the essential objective function, and thus has no way of knowing if some of the candidate solutions are near to or distance from a local or global max.

PSO Algorithm and Flow Chart:

The PSO algorithm have just three steps, which are repeated in anticipation of some stopping condition is meet up.

1. Evaluate the fitness of each particle
2. Update individual and global best fitness and positions
3. Update velocity and position of each particle

Flow Chart of Proposed PSO Algorithm

The velocity is generally limited to a certain maximum value. PSO using Eq. (4) is called the model. The particles in the swarm are accelerated to new positions by adding new velocities to their present positions. The new velocities are calculated using Eq. (4) and positions of the particles are updated using Eq. (5).

Implementation of Classical PSO for ELD solution

The main objective of ELD is to obtain the amount of real power to be generated by each committed generator, while Achieving a minimum generation cost within the constraints. The details of the implementation of PSO components are summarized in the following subsections.

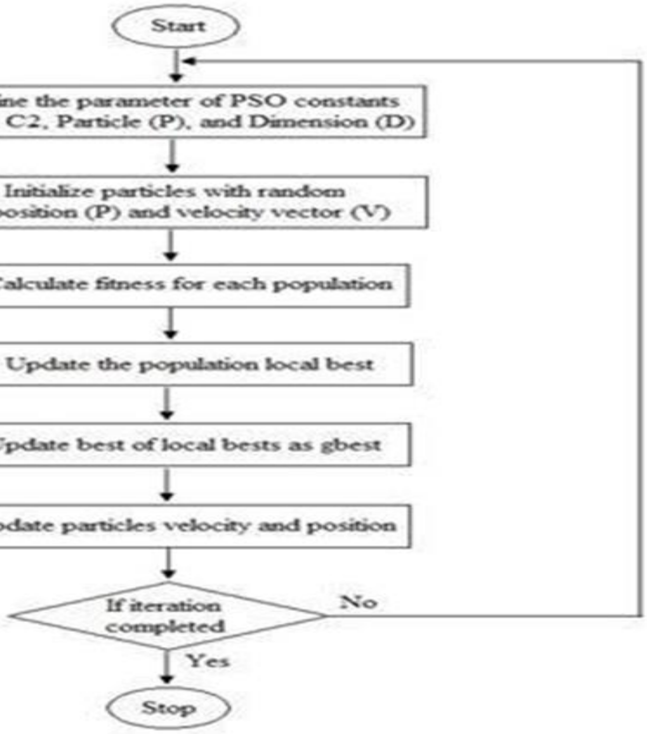


FIGURE-I

The search procedure for calculating the optimal generation quantity of each unit is summarized as follows:
1. Initialization of the swarm: For a population size P, the particles are randomly generated in the range 0-1 and located between the maximum and the minimum operating limits of the generators. If there are N generating units, the ith particle is represented as
Pi = (Pi1, Pi2, Pi3……………... N).
The jth dimension of the ith particle is allocated a value of Pij as given below to satisfy the constraints.
Pij = Pjmin + r (Pjmax - Pjmin)
Here r [0,1]

- Defining the evaluation function: The merit of each individual particle in the swarm is found using a fitness function called evaluation function. The popular penalty function method employs functions to reduce the fitness of the particle in proportion to the magnitude of the equality constraint violation. The evaluation function is defined to minimize the non-smooth cost function given by equation The evaluation function is given as Min f(x)=f(x)+ lambda (equality constraints)

3. Initialization of P-best and G-best: The fitness values obtained above for the initial particles of the swarm are set as the initial Pbest values of the particle. The best value among all the Pbest values is identified as G-Best.
4. Evaluation of velocity: The update in velocity is done by equation (6).
5. Check the velocity constraints of the members of each individual from the following conditions.If, Vid (k+1) >Vd max, then Vid (k+1) = vd max, (6)
Vid (k+1) <Vd min then, Vid (k+1)=vd min
Where, Vdmin = -0.5 Pgmin, Vdmax = +0.5 Pg max
6. Modify the member position of each individual Pg according to the equation
Pgid (k+1) = Pgid (i) + Vid (k+1)
Pgid (k+1) must satisfy the constraints, namely the generating limits. If Pgid (k+1) violates the constraints, then Pgid (k+1) must be modified towards the nearest margin of the feasible solution.

7. If the evaluation value of each individual is better than previous P-best, the current value is set to be P-best. If the best P-best is better than G-best, the best P-best is set to be G-best. The corresponding value of fitness function is saved.
8. If the number of iterations reaches the maximum, then go to step 10. Otherwise, go to step-2.

III. TEST SYSTEM, RESULTS AND DISCUSSION

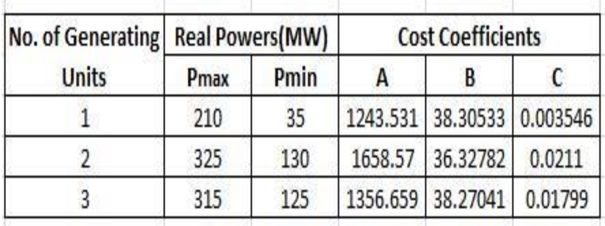
The results and discussion may be combined into a common section or obtainable separately. They may also be
In order to show the effectiveness of the Proposed PSO Algorithm for Short-term Load dispatch Problem, three different types of test systems have been taken into consideration: 3 Units, 5 Units and 6 Units

- The first test system consists of 5-Generating units has been taken from IEEE 14-Bus System with a time varying load demand for one day.
- The second test system consists of 3 and 6 Generating units has been taken from other research technique in power System with a time varying load demand.

The corresponding results has been obtained using Particle Swarm optimization Technique using Population Size=50 and Maximum Iteration=30000. The Flow chart for ELDP using swarm optimization technique is shown in Figure-1. The MATLAB Simulation software 7.12.0 (R2011a) is used to obtain the corresponding results.

Test System-I

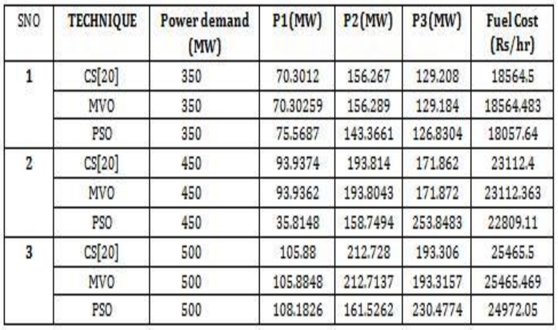
Table-I: Generator characteristics of 3-Unit TestSystem



No. of Generating Units	Real Powers(MW)		Cost Coefficients		
	Pmax	Pmin	A	B	C
1	210	35	1243.531	38.30533	0.003546
2	325	130	1658.57	36.32782	0.0211
3	315	125	1356.659	38.27041	0.01799

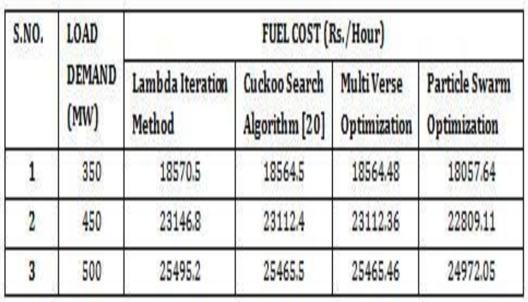
The loss coefficient matrix for 3-unit system:
□ 0.000071 0.000030 0.000025□*B* □□□0.000030 0.000069 0.000032□□

Table-II: Result of 3-Unit generation System



SNO	TECHNIQUE	Power demand (MW)	P1(MW)	P2(MW)	P3(MW)	Fuel Cost (Rs/hr)
1	CS[20]	350	70.3012	156.267	129.208	18564.5
	MVO	350	70.30259	156.289	129.184	18564.483
	PSO	350	75.5687	143.3661	126.8304	18057.64
2	CS[20]	450	93.9374	193.814	171.862	23112.4
	MVO	450	93.9362	193.8043	171.872	23112.363
	PSO	450	35.8148	158.7494	253.8483	22809.11
3	CS[20]	500	105.88	212.728	193.306	25465.5
	MVO	500	105.8848	212.7137	193.3157	25465.469
	PSO	500	108.1826	161.5262	230.4774	24972.05

Table-III: Comparison of result of 3-Unit generation System



S.NO.	LOAD DEMAND (MW)	FUEL COST (Rs./Hour)			
		Lambda Iteration Method	Cuckoo Search Algorithm [20]	Multi Verse Optimization	Particle Swarm Optimization
1	350	18570.5	18564.5	18564.48	18057.64
2	450	23146.8	23112.4	23112.36	22809.11
3	500	25495.2	25465.5	25465.46	24972.05

Test System-II

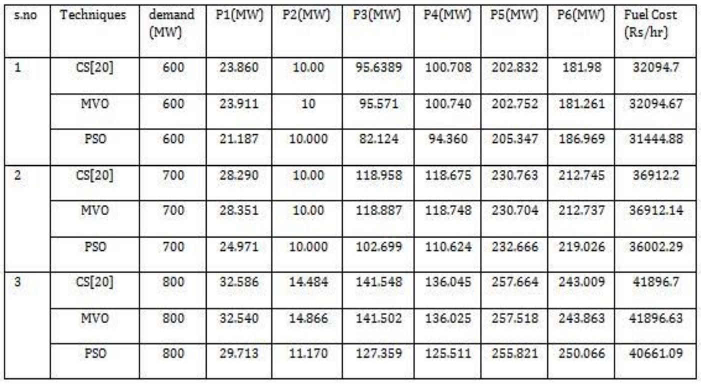
Table-IV: Generator characteristics of 6-Unit test System

No. of Generating Units	Real Powers(MW)		Cost Coefficients		
	Pmax	Pmin	A	B	C
1	125	10	756.7989	38.53	0.15240
2	150	10	451.3251	46.15916	0.10587
3	225	35	1049.998	40.39655	0.02803
4	210	35	1243.531	38.30553	0.03546
5	325	130	1658.57	36.32782	0.02111
6	315	125	1356.659	38.27041	0.01799

The loss coefficient matrix for 6-unit system

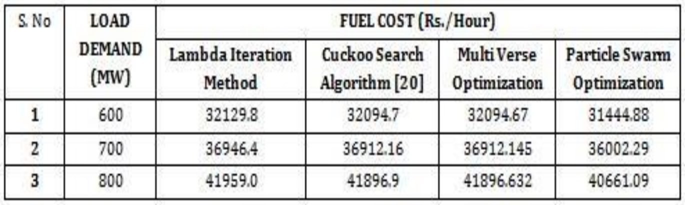
$$B = \begin{bmatrix} 0.000022 & 0.000020 & 0.000019 & 0.000025 & 0.000032 & 0.000085 \\ 0.000026 & 0.000015 & 0.000024 & 0.000030 & 0.000069 & 0.000032 \\ 0.000019 & 0.000016 & 0.000017 & 0.000071 & 0.000030 & 0.000025 \\ 0.000015 & 0.000013 & 0.000065 & 0.000017 & 0.000024 & 0.000019 \\ 0.000017 & 0.000060 & 0.000013 & 0.000016 & 0.000015 & 0.000020 \\ 0.00014 & 0.000017 & 0.000015 & 0.000019 & 0.000026 & 0.000022 \end{bmatrix}$$

Table-V: Result of 6-Unit generation System



s.no	Techniques	demand (MW)	P1(MW)	P2(MW)	P3(MW)	P4(MW)	P5(MW)	P6(MW)	Fuel Cost (Rs/hr)
1	CS[20]	600	23.860	10.00	95.6389	100.708	202.832	181.98	32094.7
	MVO	600	23.911	10	95.571	100.740	202.752	181.261	32094.67
	PSO	600	21.187	10.000	82.124	94.360	205.347	186.969	31444.88
2	CS[20]	700	28.290	10.00	118.958	118.675	230.763	212.745	36912.2
	MVO	700	28.351	10.00	118.887	118.748	230.704	212.737	36912.14
	PSO	700	24.971	10.000	102.699	110.624	232.666	219.026	36002.29
3	CS[20]	800	32.586	14.484	141.548	136.045	257.664	243.009	41896.7
	MVO	800	32.540	14.866	141.502	136.025	257.518	243.863	41896.63
	PSO	800	29.713	11.170	127.359	125.511	255.821	250.066	40661.09

Table-VI: Comparison of result of 6-Unit generation System



S. No	LOAD DEMAND (MW)	FUEL COST (Rs./Hour)			
		Lambda Iteration Method	Cuckoo Search Algorithm [20]	Multi Verse Optimization	Particle Swarm Optimization
1	600	32129.8	32094.7	32094.67	31444.88
2	700	36946.4	36912.16	36912.145	36002.29
3	800	41959.0	41896.9	41896.632	40661.09

Table-VII: Generator characteristics of 5-Unit Test System

UNITS	Pmax	Pmin	A	B	C
Unit1	250	10	0.00315	2	0
Unit2	140	20	0.0175	1.75	0
Unit3	100	15	0.0625	1	0
Unit4	120	10	0.00834	3.25	0
Unit5	45	10	0.025	3	0

IV. CONCLUSION

In this research paper, researchers have presented the solution of Economic load dispatch Problem solution using Swarm Optimization technique. The results of 3units, 5 units and 6 Generating units have been successfully evaluated using Swarm Optimization technique. The following important points are observed throughout the research findings:

- By proposed Swarm Optimization technique, Fuel cost (FC) is less than multi verse optimization technique.
- Proposed algorithm has simple implementation, require less computational time and very few algorithm parameters.

V. FUTURE SCOPE

(1) Swarm Optimization technique is based on the intelligence. It can be applied into both scientific research and engineering use.

(2)

This technique has no overlapping and mutation calculation so calculation of generation parameter can easy calculate. During the development of several generations, only the most optimist particle can transmit information on to the matlab programe.

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