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A Comprehensive Study On Combined Economic and Emission Dispatch Optimization Problem

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Abstract: *The Paper Reviews about the Recent Trends in Economic Dispatch Problem Which Turn has To promote the increase in the number of power generating stations and their capacity of generation. The consequent increase in power transmission lines connects the generating stations to the load centers. The generation of electricity from fossil fuel releases several contaminated elements, such as Sulphur Dioxide (SO2), Nitrogen Oxides (NOx) and Carbon Dioxide (CO2) Which leads to the formulation of combined economic and emission dispatch (CEED) problem. Current researchers are developing various natural inspired algorithms to eliminate the combined economic and emission dispatch (CEED) problem. This paper presents a review ON economic load and emission dispatch (CEED) PROBLEMS which are solved by different techniques.*
Keywords: *Optimum power flow, CEED, CO_2, RGA, RBF,ABC.*

I. Introduction

Today electrical power plays a strategic role in all walks of life of an individual as well as the community. The development of various sectors such as transportation, industrial, agricultural, information and communication sectors etc. depends on electrical energy. Combine Economic and Emission Dispatch (CEED) problem allocate optimal power generation among the committed units which minimizes fuel cost as well as the amount of emission while fulfilling all the operational constraints of the system. The generation of electricity from fossil fuel discharges debased components, For example Sulphur Dioxide (SO2), Nitrogen Oxides (NOx) and Carbon Dioxide (CO2) are pollute the environment. Atmospheric influences all organizations of life and also causes global warming. Due to increasing concern over the environment and the passage of US clean air act amendments of 1990[ ], utilities are forced to modify their strategies for power generation not only at minimum cost but also at minimum emission level. Therefore it is necessary to find out an operating point, that strikes a balance between cost and emission. This can be achieved by combined economic and emission dispatch (CEED).

The economic dispatch problem has been solved via many traditional optimization methods, including: Gradient-based techniques, Newton methods, linear programming, and quadratic programming. The greater part of these methods are not equipped for taking care of effectively advanced issues with a non-curved, nonstop and exceedingly non-straight arrangement [2].

These methods need to derivative about of the objective function, which give non acceptable results and require expansive computational time for non-linear complex problem. Direct programming experiences the constraint method as it require piecewise linear cost approximation. Newton based methods struggle with handling large numbers of inequality constraints.

Conventional methods lack to solve this complex problem and may get struck to local minimum. Hence to search the global minimum intelligent techniques may be used. Recently various heuristic intelligent techniques such as Redefined Genetic Algorithm (RGA), Modulated Particle Swarm Optimization (MPSO), Gravitational Search Algorithm (GSA), Radial Basis Function (RBF) Flower Pollination Algorithm (FPA) and other alternative methods have been used to solve complex optimization problem [5].

II. Conventional Techniques

Further, many objective functions and constraints must be satisfied for power systems economic operation. Existing methods for solving the economic dispatch problem solve it as a function of time using different constraints of the system. It uses mathematical techniques such as:

1. Newton Raphson (NR)
2. Lambda Iteration method
3. Interior point method
4. Linear programming(LP)

2.1 . Newton Raphson Method

This Method describes the well known for solution of Power Flow. It has been the standard solution algorithm for the power flow problem for a long time The Newton approach is a flexible formulation that can be adopted to develop different OPF algorithms suited to the requirements of different applications.

Merits and Demerits of Newton Raphson Method:

Merits:

a. The Newton approach is a flexible formulation that can be used to develop different algorithms to the requirements of different applications.
b. With this method efficient and robust solutions can be obtained for problems of any practical size
c. There is no need of user supplied tuning and scaling factors for the optimization process.

Demerits

a. The penalty near the limit is very small by which the optimal solution tend to the variable to float over the limit
b. It is not possible to develop practical OPF programs without employing sparsest techniques.
c. Newton based techniques have a drawback of the convergence characteristics that are sensitive to the initial conditions and they may even fail to converge due to inappropriate initial conditions

2.2. Linear Programming Method

The Linear Programming approach has been advocated on the grounds that

a. The L.P solution process is completely reliable.
b. The L.P solutions can be very fast. The accuracy and scope of linearised model is adequate for most engineering purposes.

It may be noted that point (a) is certainly true while point (b) depends on the specific algorithms and problem formulations. The observation (c) is frequently valid since the transmission network is quasi linear, but it needs to be checked out for any application.

Merits and Demerits of Linear Programming Method:

The Merits and Demerits of Linear Programming Methods are summarized and given below.

Merits:

a. The LP method easily handles Non linearity constraint.
b. The advantages of LP approach, such as, complete computational reliability and very high speed enables it, suitable for real time or steady mode purpose.

Demerits:

a. It suffers from lack of accuracy.
b. Although LP methods are fast and reliable, but they have some disadvantages associated with the piecewise linear cost approximations.

2.3. Quadratic Programming Method:

Quadratic Programming (QP) is a special form of NLP. The objective function of QP optimization model is quadratic and the constraints are in linear form. Quadratic Programming has higher accuracy than LP – based approaches. Especially the most often used objective function is a quadratic.

Quadratic Programming based optimization is involved in power systems for maintaining a desired voltage profile, maximizing power flow and minimizing generation cost.

Merits and Demerits of Quadratic Programming Method:

The Merits and Demerits of Quadratic Programming Method are summarized and given below.

Merits:

a. The method is suited to infeasible or divergent starting points.
b. The method can solve both the load flow and economic dispatch problems.
c. The Quadratic Programming method does not require the use of penalty factors or the determination of gradient step size which can cause convergence difficulties. In this way convergence is very fast.

Demerits:

a. Difficulties in obtaining solution of quadratic programming in large dimension of approximating QP problems.
b. QP based techniques have some disadvantages associated with the piecewise quadratic cost approximations.

2.4. Interior Point Method:

The Interior Point Method (IPM) can solve a large scale linear programming problem by moving through the interior, rather than the boundary as in the simplex method of the feasible reason to find an optimal solution. The IP method was originally proposed to solve linear programming problems; however later it was implemented to efficiently handle quadratic programming problems..

Merits and Demerits of Interior Point Method:

The Merits and Demerits of interior Method are summarized and given below.

Merits:

a. The Interior Point Method is one of the most efficient algorithms.
b. Maintains accuracy while achieving great advantages in speed while convergence.
c. The Interior Point Method is preferably adapted to OPF due to its reliability, speed and accuracy

Demerits:

a. Limitation due to starting and terminating conditions.
b. Infeasible solution if step size is chosen improperly.

The drawbacks of conventional methods. All of them can be summarized as three major problems. Firstly, they may not be able to provide optimal solution and usually get stuck at a local optimal. Secondly, all these methods are based on assumption of continuity and differentiability of objective function which is not actually allowed in a practical system Finally, all these methods cannot be applied with discrete variables, which are transformer tap.

III. Natural Inspired Algorithms

3.1. Genetic Algorithm

Genetic Algorithm (GA), first introduced by John Holland in early seventies, is becoming a flagship among various techniques of machine learning and function optimization. Algorithm is a set of sequential steps needs to be executed in order to achieve a task. A GA is an algorithm with some of the principles of genetics included in it. The genetic principles "Natural Selection" and "Evolution Theory" are main guiding principles in the implementation of GA. The GA combines the adaptive nature of the natural genetics and search is carried out through randomized information guiding principles in the implementation of GA.

GA works with a coding of the parameter set and not the parameters themselves.

GA searches from a population of point and not from a single point like conventional algorithms. GA uses objective function information, not derivative or other auxiliary data.

3.2. Types of Genetic Algorithm

Based on the combinations of operators and strategies, GA's are classified in to three. types.

Simple Genetic Algorithm: In this multipoint crossover and mutation are the operators used and Roulette Wheel Selection is the selection technique.

Refined Genetic Algorithm: In this uniform crossover and mutation are the operators and Roulette Wheel election is the selection technique. Strategies like Elitism changing Pc and Pm are also implemented..

3.3 Refined Genetic Algorithm:

David Goldberg's proposed Simple Genetic Algorithm (SGA) to solving optimization problems. The results generated are acceptable, yet still need to improve. Since the loss of accuracy, increase cost, especially with respect to the ED Flow chart for Refined Genetic Algorithm can be shown in fig 1.

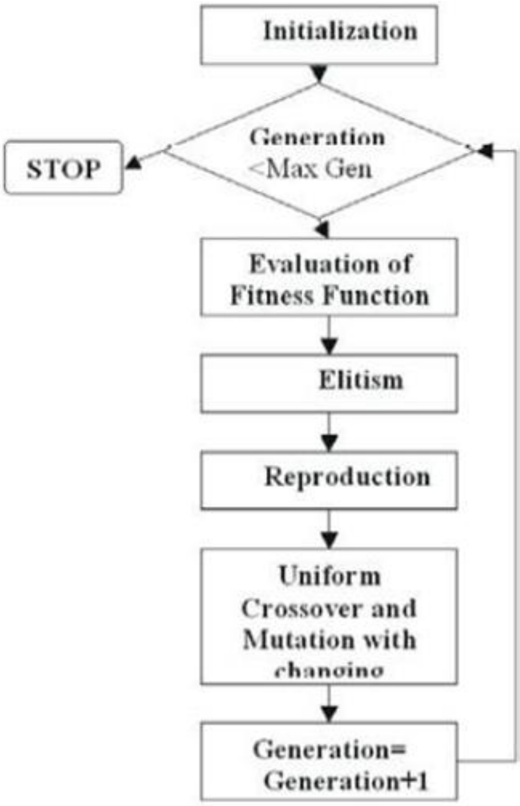

Fig 1. Flow chart for Refined Genetic Algorithm.

In Refined Genetic Algorithm there are four important parameters named as Elitism Reproduction and uniform cross over and mutation

3.4. Problem Formulation to ED:

Combined Economic Emission Dispatch problem, have the goal is to minimize the objective function.

$$F_{obj} = \sum_{i=1}^{N} Fi(Pi) + g\sum_{i=1}^{N} Ei(Pi) \qquad \text{… Eqa(1)}$$

with the constraint of equality.

$$\sum_{i=1}^{N} Pi - Ploss - Ploads = 0 \qquad \text{… Eqa(2)}$$

is changed to unconstrained optimization problem and thus forming the fitness function

$$F_{cr} = \sum_{i=1}^{N} Fi(Pi) + g\sum_{i=1}^{N} Eij(Pi) + PF(\sum_{i=1}^{N} Pi - Ploss| \qquad \text{… Eqa(3)}$$

3.5 Evaluation of Fitness Function:

The evaluation of fitness function for each string is based on the formation its size, population and is very much suitable for applications. Since the GA proceeds in the direction of important solving better fit strings and the fitness value is the only information available to the GA. The performance of the algorithm is highly sensitive to the fitness values. The objective function is to minimize fuel cost and NOX emission. So the Fitness functions shown in Eqa… (4).

$$\text{Fit}[i] = 1.0 / (\sum_{i=1}^{N} F_i\ (P_i) + g\sum_{i=1}^{N} E_{ij}\ (P_i) + PF \qquad \text{… Eqa(4)}$$

Where

N = Number of generating units PF = Power balance penalty factor g = Price penalty factor (Rs/Kg).

Merits and Demerits of Genetic Algorithm:
The Merits and Demerits of Genetic Algorithm are summarized and given below

Merits:
a. GAs can handle the Integer or discrete variables.
b. GAs can provide a globally optimum solution as it can avoid the trap of local optima.
c. GAs can deal with the non-smooth, non continuous, non-convex and non differentiable functions which actually exist in practical optimization problems.
d. GAs can be easily coded to work on parallel computers

Demerits:
a. GAs are stochastic algorithms and the solution they provide to the OPF problem is not guaranteed to be optimum.
b. The execution time and the quality of the solution, deteriorate with the increase of the chromosome length, i.e., the OPF problem size

IV. Radial Basis Function (RBF) Networks:

4.1. Introduction

RBF method alternative approach to Multilayer Perception (MLP) in universal function approximation. RBFs were first used in solving multivariate interpolation problems and numerical analysis. Their prospect is similar in neural network applications; the training and query target are continuous. The units (in the hidden layer) receiving the direct input from a signal may see only a portion of the input pattern, which is further used in inter constructing a surface in a multidimensional space that furnishes the best-fit to the training data. This is the special ability of the RBF network to recognize whether an input is near the training set or outside the trained region.

4.2 RBF Network Structure:

Fig (2) represents the RBF structure and it consists of multilayer perception model.

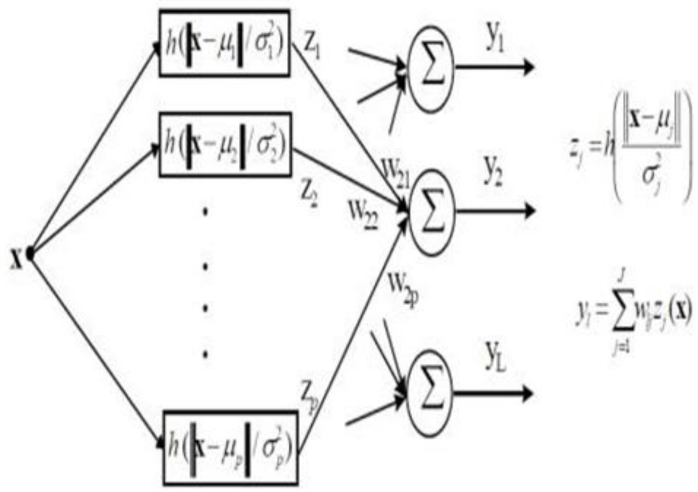

Fig. 2 Radial Basis Function Structure.

A typical RBF network is a two layer network having Input Layer of the dimension of training patterns Hidden Layer of up to locally tuned neurons centered over receptive fields for non-linear, local mapping. Output layer that provides the response of the network.

h0 is a strictly positive radially symmetric function with a unique maximum at it center μj, and which drops off rapidly to zero away from the center. In other words, zj -has an appreciable value only when the "distance" |x −μ j| is smaller than the width σj.

4.3. Methods for Selection of Centers:

a. Fixed: When the number of hidden neurons equals the number of patterns, each pattern may be taken to be a center of a particular neuron. Therefore, the centers are vectors of the dimension of the input

b. Kohonen Selection of Centers: K patterns are to be selected from the set n teaching patterns acting as starting values for the center vectors. The vectors are normalized to length 1, and the scalar product between one teaching pattern and each center vector is computed to give a measure for the distance between the two multiplied vectors.

c. Using K-Means Cluster Centers:

The objective is to locate a “set k of RBF centers that represent a local minimum of the SSE between the training set vectors x and the nearest of the k receptive field centers μj.” In other words, the k RBF’s are initially assigned centers μj, j=1, 2, …,k, which are set equal to k randomly selected training vectors..

4.4. Methods for Selection of Widths:

a. Fixed: When the centers are fixed from the input data, the widths may be calculated as

$$\sigma = \frac{d}{\sqrt{2M}} \qquad \text{… Eqa(5)}$$

where d is the maximum distance between the chosen centers and M is the number of centers (RBF’s)

b. Distance Averaging a reasonable estimate for the global width parameter is the average of

$$\sigma_j = \left\langle \left\| \mu_i - \mu_j \right\| \right\rangle , \qquad \text{… Eqa(6)}$$

which represents a global average over all Euclidean distances between the center of each unit i and that of its nearest neighbor j.

4.5. Implementation Of Ceed Using Radial Basis Function Network

The below flow chart represents that weighted functions can be reduced by using clustering technique.

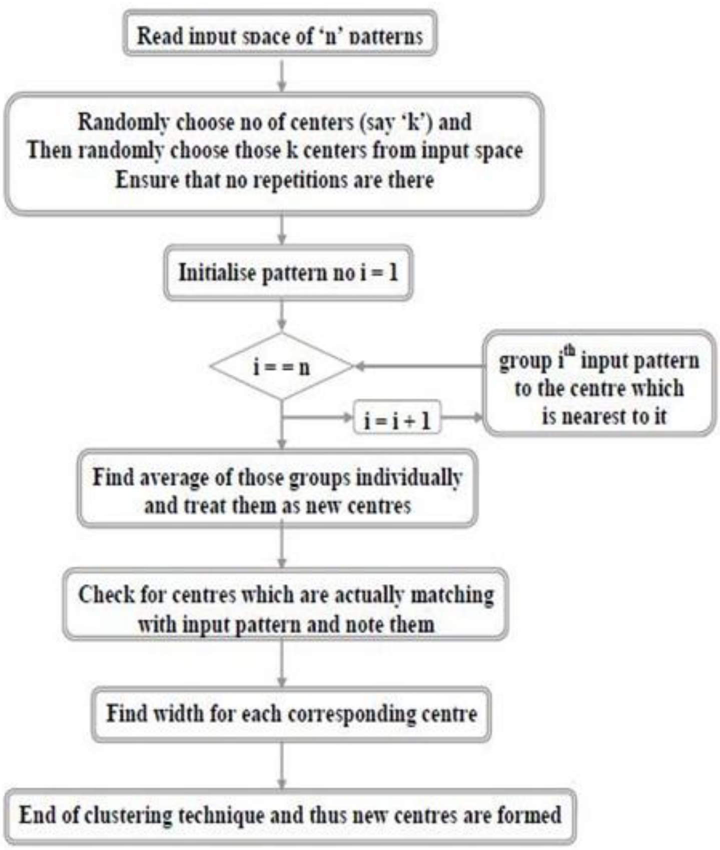

Fig.3. flow chart of clustering technique

The RBF network response is expressed in terms of the function f(x) which should be an approximation of the p given pairs {( )} p i i i y 1, = x and should therefore minimize the following criterion (error) function

$$C=\sum_{i=1}^{p}(y_i-f(\mathbf{x}_i))^2+\sum_{j=1}^{m}\lambda_j w_j^2 \text{ such that } f(\mathbf{x})=\sum_{i=1}^{m}w_j h_j(\mathbf{x}) \quad \text{… Eqa(7)}$$

i = 1…..., p (p = number of training input patterns) j = 1, …, m (m = number of hidden neurons)

where the first term minimizes the total error of the approximation, the second term (weight penalty) is referred to as the Regularizing Term (or The Stabilizer) and forces f(x) to become as smooth as possible (weight decay) since large weights produce rough output functions and the weighted functions can be minimized by using the flow chart.

4.6. Advantages of an RBF

Many advantages are claimed for RBF networks over Multi-Layer Perceptions (MLPs). It is said that a RBF trains faster than a MLP and that it produces better decision boundaries. Another advantage that is claimed is that the hidden layer is easier to interpret than the hidden layer in an MLP. Some of the disadvantages that are claimed for an RBF are that an MLP gives better distributed representation. Although the RBF is quick to train, when training is finished and it is being used it is slower than an MLP, so where speed is a factor an MLP may be more appropriation.

V. Gravitational Search Algorithm:

A GSA streamlining calculation has been proposed and effectively connected to take care of the CEED issue. Reenactment comes about demonstrate that the GSA approach gives compelling and vigorous high. Quality arrangement. The merging qualities of GSA for the fuel cost, NOx discharge and combined fuel expense and NOx emanation minimization individually quality arrangement.

In addition, the outcomes acquired utilizing GSA are either better or practically identical to those got utilizing different methods The joining qualities of GSA for the fuel cost, NOx emanation and consolidated fuel expense and NOx outflow minimization individually [17].

GSA is one of the latest heuristic calculations enhanced for taking care of advancement issues. GSA is effectively connected to tackle a joined financial and outflow dispatch issue.

The CEED issues detailed as a bi-target streamlining issue and the proposed methodology is tried on four diverse test frameworks.

Firstly, GSA is tried on six generators and eleven-generators, with a quadratic cost capacity for consolidated financial discharge load dispatch issues.

Also, the proposed calculation is connected to ten generators and forty generators, with a non smooth cost capacity for CEED issues.

The simulation result exhibit the viability and power of the proposed approach in taking care of the CEED issue under different test frameworks. In addition, the consequences of the proposed GSA method have been contrasted with those procedures distributed in their approach. It is seen from the correlation that the proposed technique affirms the compelling solutions for CEED issues.

GSA method is not exactly other streamlining methods [18]. Considering the power limits, to solve the combined economic emission dispatch problem with linear equality and inequality constraints and transmission losses. Economic and emission dispatch is a multi-objective problem. But the present approach makes use of only one objective function and depending upon the problem such as economic, emission or combined economic and emission dispatch, only the coefficients of the objective function has been changed. The feasibility of the proposed method for solving CEED problems is demonstrated on IEEE 30-bus test system with six generating units. The comparisons of the results with other methods are reported the literature shows the superiority of the proposed method and its potential for solving CEED problems in a power system. From the results it has demonstrate the MABC algorithm is a promising technique for solving complex optimization problems in power system operation. This paper shows minimum fuel cost and emission for CEED problem with all load demand [19].

VI. Artificial Bee Colony Algorithm:

A new optimization of artificial bee colony (ABC) algorithm has been solved to CEED problem with three and six generating unit. The results obtained in this method were compared to those conventional methods, RGA and SGA and Hybrid GA. The comparison shows that ABC algorithm performs better then above mentioned methods. The ABC algorithm has superior features, including quality of solution, stable convergence characteristics and good computational efficiency. Therefore, this paper shows results that ABC optimization is a promising technique for solving complicated problems in terms of minimum fuel cost, emission level and total operating cost [20].

The literature presents exhibitions of a harvesting season manufactured honey bee settlement (HSABC) calculation for acquiring the best arrangement of a consolidated financial and outflow dispatch (CEED). HSABC for tackling CEED issue utilizing IEEE-30bus. Through the outcomes acquired, it is presumed that HSABC utilized a CDP system can create better exhibitions, both position techniques showed in smooth merging velocities, HSABC utilized CDP is speed than one of UDP, [21].

An adaptable and productive variation based honey bee settlement named move honey bee state with element step size change has been effectively adjusted and connected for unraveling multi-objective financial emanation dispatch considering valve point impact and aggregate transmission misfortunes. The exploit of the proposed approach has been tried and accepted on two standard test frameworks, IEEE 30bus. Considering power misfortunes and to the huge test framework with 40 units considering valve point impact. It is watched that the proposed variation is competent to upgrading the arrangement of the consolidated monetary outflow dispatch considering down to earth generator requirements. It has been considerable of three cases gives minimization fuel cost, minimization emission, minimization of cost and discharge [22].

This paper reviews a comparison of ABC's for taking care of a CEED issue utilizing IEEE-62 bus as a specimen framework. The reproductions equity and imbalance signify the proposed techniques for originated two fundamental commitments. The main commitment is proposed calculation couple of parameters to be tuned. Moreover, exploratory results are demonstrated the proposed calculations, effectiveness and strength for both little and extensive size issue occurrences. The second commitment of this paper is about parameter design strategy. Each met heuristic calculation shows a predefined set of parameters which must be instated before an execution. This paper indicates minimization of fuel cost and NOx outflow rate that are ascertained after every [24].

VII. Conclusion:

Finally the review paper concludes mainstream procedures of Combined Economic and Emission Dispatch (CEED) problem. Covering both customary and keen for each of the ordinary and astute system. The commitment by researchers has been secured as a review paper. Which helps the researchers to rapidly become easily acquainted with the noteworthy commitments and striking components of the commitment made by analysts according to the references specified. This paper incorporates examination on traditional techniques and the knowledge strategies taking into account customary calculation, Radial Basis Function, Gravitational Algorithm and Artificial Bee colony calculation, and other alternated method were studied

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