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Solving Economic Load Dispatch Problem Using Traditional Optimization Technique with Competitive Study

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Abstract-: Economic load dispatch problem is a common task in the operational planning of a power system, which requires to be optimized. This paper presents an effective and reliable technique for the economic load dispatch problem. The results have been demonstrated for Economic load dispatch of standard 3-generator and 15-generator systems without consideration of transmission losses and with transmission losses. The final results obtained using GAMS are compared 3 unit systems with proposed PSO algorithm and Conventional Algebraic method and 15 unit system are compared proposed Algorithm, PSO Method and GA method found to be encouraging

Index Terms- Economic Load Dispatch, PSO, GA, GAMS.

1. INTRODUCTION

Economic load dispatch (ELD) problem is one of the non-linear optimization problems in electrical power systems in which the main objective is to reduce the total power generation cost. The objective of the Economic Dispatch Problems (EDPs) of electric power generation is to schedule the committed generating units outputs so as to meet the required load demand at minimum operating cost while satisfying all units and system equality and inequality constraints [1]. The ELD seeks the best 'generation schedules for the generate plants to supply the essential the total coupled power demand plus transmission losses at least production cost. Economic load dispatch (ELD) is the online dispatch which is used for the distribution of load among the generating units [2]. The fuel cost curve characteristic is nonlinear due to presence of various equality and inequality constraints, Economic load dispatch (ELD) seeks ―the best‖ generation schedule for the generating plants to supply the required demand plus transmission losses at minimum production cost. Various investigations on ELD have been undertaken until date, as better solutions would result in significant economical benefits. Previously a number of derivative based approaches including Lagrangian multiplier method have been applied to solve ELD problems [3].Many works have been around as Artificial Neural Networks (ANN) [4], Particle Swarm Optimization (PSO) [5], Genetic Algorithms (GA) [6], Evolutionary Programming (EP) [7] Differential Evolution (DE) [8].Conventional as well as modern methods have been used for solving economic load dispatch, various conventional methods like nonlinear programming , mixed integer linear programming [9 , Quadratic programming [10], Reported in the literature are used to solve such problems.

The proposed method focuses on solving the economic load dispatch with Generator Ramp Rate Limits constraint. The feasibility of the proposed method was demonstrated for 3 bus system and 15 bus

Systems. The results obtained through the proposed approach and compared with those reported in recent literatures.

2. THE INTRODUCTION OF PROPOSED OPTIMIZATION TECHNIQUE GENERAL ALGEBRAIC MODELING SYSTEM

The General Algebraic Modeling System (GAMS) is a high-level modeling system for mathematical programming and optimization. It consists of a language compiler and a stable of integrated high-performance solvers. GAMS is tailored for complex, large scale modeling applications, and allows you to build large maintainable models that can be adapted quickly to new situations. The General Algebraic Modeling System (GAMS) is specifically designed for modeling linear, nonlinear and mixed integer optimization problems. The system is especially useful with large, complex problems. GAMS are available for use on personal computers, workstations, mainframes and supercomputers. GAMS allow the user to concentrate on the modeling problem by making the setup simple. The system takes care of the time-consuming details of the specific machine and system software implementation [11].

2.1 Model Libraries

The models in the GAMS Model Library have been selected because they represent interesting and sometimes classic problems. Examples of problems included in the library are production and shipment by firms, investment planning, cropping patterns in agriculture, operation of oil refineries and petrochemical plants, macroeconomics stabilization, applied general equilibrium, international trade in aluminum and in copper, water distribution networks, and many more. In GAMS model library another criterion for including a model in the library is that it illustrates the modeling capabilities GAMS offers. For example, the mathematical specification of cropping patterns can be represented handily in GAMS. A further example of the system's capability is the style for specifying an initial solution as a starting point in the search for the optimal solution of dynamic nonlinear optimization problems [12-13].

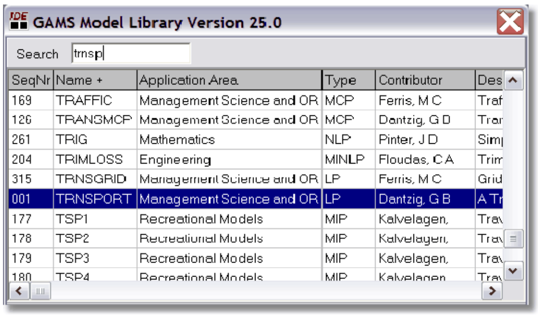

Fig 1 GAMS model library

2.2 Programme Features of GAMS

The most important features of GAMS are:

- ➢ The model is independent from the solution method, and it can be solved by different solutions methods by only changing the solver.
- ➢ The translation from the mathematical model to GAMS is almost transparent since GAMS has been built to resemble mathematical programming models.
- ➢ Efficient handling of mathematical optimization problems.
- ➢ Increase productivity and support maintainable models
- ➢ Easy to apply (and compare) different solvers

3. CLASSICAL ECONOMIC LOAD DISPATCH PROBLEM

The objective of the economic dispatch problem is to minimize the total fuel cost at thermal power plants subjected to the operating constraints of a power system [14]. Therefore, it can be formulated mathematically with an objective function and two constraints. The equality and inequality constraints are represented by (1) and (2) given by

$$\sum P_i - (P_d + P_l) = 0 \quad (1)$$

$$P_{imin} \leq P_i \leq P_{imax} \quad (2)$$

For a given total real load PD the system loss PL is a function of active power generation at each generating unit. To calculate system losses, methods based on penalty factors and constant loss formula coefficients or B-coefficients. The latter is adopted in this paper as per which transmission losses are expressed as

$$P_L = \sum_{i=1}^{N} \sum_{j=1}^{N} P_i B_{ij} P_j + \sum_{i=1}^{N} B_{oi} P_i + B_{oo} \quad (3)$$

In the power balance criterion, an equality constraint must be satisfied, as shown in (1). The generated power should be the same as the total load demand plus total line losses. The generating power of each generator should lie between maximum and minimum limits represented by (2), where Pi is the power of its generator in MW; n is the number of generators in the system; PD is the system total demand in MW; represents the total line losses (in MW); and are, respectively, the output of the minimum and maximum operation of the generating unit (in MW). The total fuel cost function is formulated as follows:

$$MinF_T = \sum_{i=1}^{N} F_i(P_i) \quad (4)$$

Where Fi is the total fuel cost for the its generator (in$/h) which is define by,

$$F_i(P_i) = (a_i P_i^2 + b_i P_i + c_i) \quad (5)$$

4. TEST SYSTEM

The Economic Load Dispatch problem based on traditional optimization technique GAMS has applied to the 3 generator and 15 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 data taken 3 units and 15 units [15], the fuel cost constants and the generator limits of a 3 generator and 15 generator systems are tabulated below in the appendix section.

***TEST SYSTEM A*:** In this test system, the traditional optimization technique GAMS was tested on the standard test system with 3 generators for the load demand of 150 MW. Table.1 and fig 2 show that the comparisons of the performance of the traditional optimization technique GAMS with the Genetic algorithm.

Table 1 comparisons of the performance of different optimization techniques

Generator output (MW)	PSO Algorithm [15]	Conventional Algebraic method [15]	GAMS
Load demand	150	150	150
P1	32.604748	33.4701	31.945
P2	64.680578	64.0974	67.247
P3	54.989919	55.1011	50.832
Transmission Loss	2.340470	2.3419	0.023
Total cost ($/h)	1596.976316	1599.98	1579.873

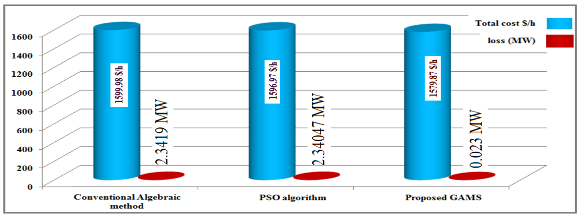

Fig 2 comparisons of the performance of different optimization techniques

***TEST SYSTEM B*:** In this test system, the traditional optimization technique GAMS was tested on the standard test system with 15 generators for the load demand of 2630 MW. Table.2 and fig 3 show that the comparisons of the performance of the traditional optimization technique GAMS with the Genetic algorithm.

Table 2 comparisons of the performance of different optimization techniques

Generator output (MW)	GA method [15]	PSO method [15]	proposed algorithm [15]	Proposed method GAMS
P1	415.31	455.00	455.000000	455.000
P2	359.72	380.00	455.000000	455.000
P3	104.43	130.00	130.000000	130.000
P4	74.99	130.00	130.000000	130.000
P5	380.28	170.00	286.412846	234.054
P6	426.79	460.00	460.000000	460.000
P7	341.32	430.00	465.000000	465.000
P8	124.79	60.00	60.000000	60.000
P9	133.14	71.05	25.000000	25.000
P10	89.26	159.85	37.560387	36.221
P11	60.06	80.00	20.000000	71.760
P12	50.00	80.00	80.000000	80.000
P13	38.77	25.00	25.000000	25.000
P14	41.94	15.00	15.000000	15.000
P15	22.64	15.00	15.000000	15.000
Transmission Loss	38.278	30.908	28.973234	27.035
Load demand	2630	2630	2630	2630
Total Cost ($/h)	33,113	32,708	32,569.951142	32550.365

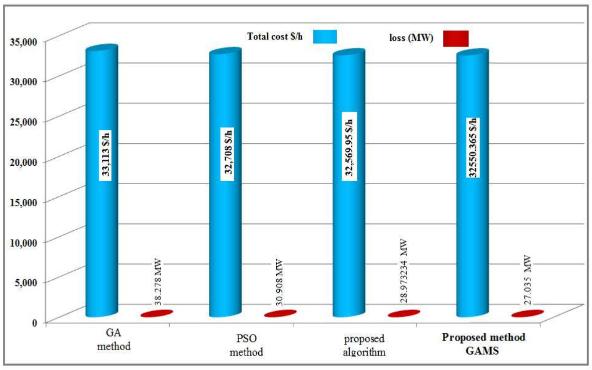

Fig 3 comparisons of the performance of different optimization techniques

5. CONCLUSION

This paper has proposed method GAMS a different approach of economic problem in power systems. The simulation results have shown that the proposed method GAMS is better than other methods in terms of the convergence characteristics and accuracy. Soft computing method like the GA, PSO and proposed PSO algorithm use achieving the optimal result in every fresh trial, the proposed GAMS methods converge to different solutions near the global best solution. The traditional NLP algorithms like the GAMS use mathematical operations to achieve the best solution so they are always consistent and converge to the unique global minimum solution. Proposed method GAMS always found solutions with global minimum or even near to global minimum of total fuel costs.

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APPENDIX

Table A1: Fuel cost coefficient of Test case A

Unit	P^{min} (MW)	P^{max} (MW)	a_i ($)	b_i ($/MW)	c_i($/MW^2)
1	10	85	200	7.00	0.0080
2	10	85	180	6.30	0.0090
3	10	70	140	6.80	0.0070

Table A2: B-loss coefficients for test case I

Bij	0.000218	0.000093	0.000028
	0.000093	0.000228	0.000017
	0.000028	0.000017	0.000179

Table 3 B1 Fuel cost coefficient of Test case B

Unit	P^{min} (MW)	P^{max} (MW)	a_i ($)	b_i ($/MW)	c_i ($/MW^2)
1	150	455	671	10.1	0.000299
2	150	455	574	10.2	0.000183
3	20	130	374	8.80	0. 001126
4	20	130	374	8.80	0. 001126
5	150	470	461	10.4	0.000205
6	135	460	630	10.1	0.000301
7	135	465	548	9.80	0.000364
8	60	300	227	11.2	0.000338
9	25	162	173	11.2	0.000807
10	25	160	175	10.7	0. 001203
11	20	80	186	10.2	0. 003586
12	20	80	230	9.90	0. 005513
13	25	85	225	13.1	0. 000371
14	15	55	309	12.1	0. 001929
15	15	55	323	12.4	0. 004447