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Power Economic Dispatch of Thermal Power Plant Using Classical Traditional Method

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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. The major issue in power system is power economic dispatch (PED) problem. Mainly it is an optimization problem and to reduce total generation cost of units is its main objective, while satisfying constraints. Economic dispatch is the short-term determination of the optimal output of a number of electricity generation facilities, to meet the system load, at the lowest possible cost, subject to transmission and operational constraints. This paper presents an application of the GAMS Method to power economic dispatch (PED) problem with Power loss for 3 & 6 generator test case systems. To power economic dispatch problems are applied and compared its solution quality and computation efficiency to GAMS Method and other optimization techniques Lambda Iteration Method. The simulation results show that the proposed GAMS Method outperforms previous optimization methods.

Keywords: Power Economic Dispatch, Lambda Iteration Method, Power Loss, GAMS

I. INTRODUCTION

Economic load dispatch is one of the key functions of modern energy management system. The 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, while satisfying various equality and inequality constraints. 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. One of the substantial operating tasks in power system is to reduce the total generation cost. The fundamental issue in modern power system operation is the ED. It is a crucial optimization problem and its main objective is to divide the required power demand among online generators The cost of power generation, particularly in fossil fuel plants, is very high and ELD helps in economy a considerable amount of profits. The Economic load dispatch is the name given to the process of apportioning the total load on a system between the various generating plants to achieve the greatest economy of operation .economic operation is very important for a power system to return a profit on the capital invested. Various investigation on ELD have been undertaken until date, as better clarification would result in major economical profit. Earlier, a number of derivatives-based approach like lambda iteration, based point input factor, gradient method and include lagrangian multiplier method have been apply to solve ELD problems There methods involve that incremental cost curves through quadratic or piecewise monotonically increasing in nature [1][2].

A various investigation has been done in this area to improve solution quality, as better solution would result in significant economical benefits. The classic problem is the economic load dispatch of generating systems to achieve minimum operating cost. For the purpose of optimum economic operation of this large scale system, modern system theory and optimization techniques are being applied with the expectation of considerable cost savings. In the past decade, a soft computing technique known as evolutionary programming [3], Genetic algorithms [4], DE [5], BBO [6-7], ABC [8] ,PSO [9-10] etc and in Literature Survey.

In this paper the used traditional classical techniques of GAMS for power economic dispatch. It requires less computation time and memory and the results are compared with the lambda method.

II. LITERATURE SURVEY

N. V. Subba Rao¹, G. Kesava Rao², S. Sivanagaraju³ [11] presented Transmission Loss allocation with Optimal Power Flow using Gravitational Search Algorithm, In deregulated power systems, the transmission loss allocation plays a key role in planning and designing of the power system. In practice, these losses should be allocated to both generators and loads depending on the amount of contribution in the total power system losses. In this paper, a new methodology to optimally allocate the transmission losses to either generators or loads based on the power flow tracing methodology is presented. In this methodology, trace usage coefficients

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are formulated to allocate transmission losses. In real time, system operator tries to minimize the transmission losses to increase the security of the system. In this paper, for the sack of analysis, the formulated OPF problem with transmission losses as objective is solved while satisfying system constraints using gravitational search algorithm. The minimized transmission losses are then allocated to either generators or loads.

Devendra Bisen [12] discusses on Dynamic Economic Load Dispatch with Emission and Loss using GAMS, Dynamic economic dispatch (DED) is a real time problem of electric power system. DED intends to schedule the online generators outputs with the predicted load demands over a certain period of time in order to operate an electric power system most economically within its security limits. This paper introduces a solution of the dynamic economic dispatch (DED) problem including the loss and emission is participated among all generating units over time interval for a system using General Algebraic Modeling System (GAMS). The objective of the collective problem can be expressed by taking the production cost including emission and losses into account with required constraints for 24 hour time interval of each generating unit. The general algebraic modeling system (GAMS) technique is guarantees the global optimality of the solution due to its look-further on capability. To validate practicability and robustness of the GAMS, it is tested on six generating unit system with different cases for determine minimum production cost of individual generating unit over a time period.

Soodabeh Soleymani, Mahdi Hayatdavudi [13] discuss Solving Economic Load Dispatch Using A Novel Method Based On PSO Algorithm And GAMS Software, Economic load dispatch (ELD) problem between power plant units is formulated as a nonlinear optimization with continuous variables. The main target in this problem is optimum planning in power plant units with minimum cost while equal and non-equal constraints consisting load request and unit production capacity are followed. In this paper an effective method based on particle swarm algorithm optimization for solving economic load dispatch optimization problem is presented which has a high ability to give optimum response in a proper time. GAMS software is used for this comparison.

Susheel Kumar Dewangan¹, Achala Jain², Dr. A.P. Huddar³ [20] presented A Traditional Approach to Solve Economic Load Dispatch Problem Considering the Generator Constraints, Economic load dispatch (ELD) problem is very important part of the power system. The purpose of economic dispatch is to determine the generation of different units in a plant such that the total fuel cost is minimum and at the same time the total demand and losses at any instant must be equal to the total generation. Many traditional methods such as lambda iteration, gradient method, Newton's method etc. are applied to determine the optimal combination of power output of all generating units so as to meet the desired demand without violation of generator constraint.

III. GENERATOR OPERATING COST

The total cost of operation includes the fuel cost, cost of labour, supplies and maintenance. Generally, cost of labour, supplies maintenance is fixed percentage of including fuel cost. The power output of fossil plant is increased sequentially by opening a set of valves to its steam turbine at the inlet. The throttling losses are large when a valve is just opened and small when it is fully opened.

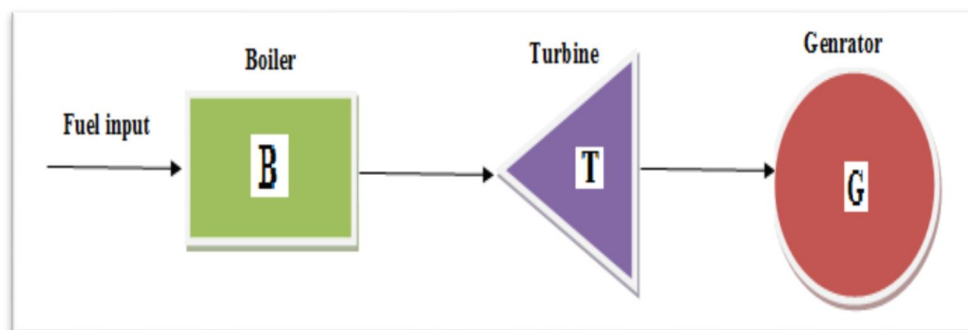


Fig1 model of a thermal plant

Fig1 show the simple model of a fossil plant dispatching purposes. The cost is usually approximated by one or more quadratic segments. The operating cost of the plant has the from shown in Fig 2 for dispatching purposes, this cost is usually approximated by one or more quadratic segments. So, the fuel cost curve in the active power generation, takes up a quadratic form. Given as:

$$F_T = \sum_{i=1}^n F_i(P_i) = \sum_{i=1}^n (a_i P_i^2 + b_i P_i + c_i) \quad 1$$

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Where

- a_i, b_i, c_i are cost coefficients for i^{th} unit
- $F(P_i)$ is the total cost of generation
- P_i is the generation of i^{th} plant

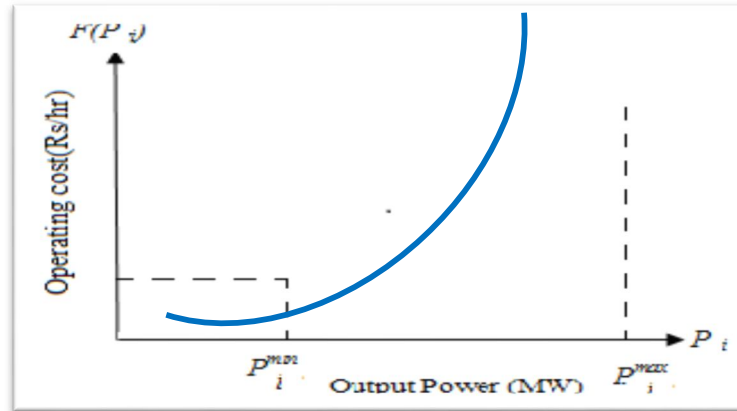


Fig 2 Operating cost of fossil fuel fired generator

The fuel cost curve may have a number of discontinuities. The discontinuities occur when the output power is extended by using additional boilers, steam condensers, or other equipment. They may also appear if the cost represents the operation of an entire power station, and hence cost has discontinuities on paralleling of generator. Within the continuity range the incremental fuel cost may be expressed by a number of short line segments or piece-wise linearization.

The P_i^{\min} is the minimum loading limit below which, operating the unit proves to be uneconomical (or may be technically infeasible) and P_i^{\max} is the maximum output limit [14]

IV. MATHEMATICAL FORMULATION OF POWER ECONOMIC DISPATCH

The objective of an ELD problem is to find the optimal combination of power generations that minimizes the total generation cost while satisfying equality and inequality constraints. The fuel cost curve for any unit is assumed to be approximated by segments of quadratic functions of the active power output of the generator. For a given power system network, the problem may be described as optimization (minimization) of total fuel cost as defined by (2) under a set of operating constraints [16].

$$F_T = \sum_{i=1}^n F_i(P_i) \tag{2}$$

Where F_T is total fuel cost of generation in the system (\$/hr),

$$F_i(P_i) = \sum_{i=1}^n (a_i P_i^2 + b_i P_i + c_i) \tag{3}$$

Where F_i is the total fuel cost for the i^{th} generator (in \$/h) which is defined by, a_i , b_i , and c_i are the cost coefficient of the i^{th} generator, P_i is the power generated by the i^{th} unit and n is the number of generators.

The total generation cost is minimized subjected to the following constraints:

Power balance constraint,

$$P_{i,\min} \leq P_i \leq P_{i,\max} \text{ for } i = 1, 2, \dots, n \tag{4}$$

Generation capacity constraint,

$$P_d = \sum_{i=1}^n P_i - P_{\text{loss}} \tag{5}$$

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Where $P_{i, \min}$ and $P_{i, \max}$ are the minimum and maximum power output of the i^{th} unit, respectively. P_d is the total load demand and P_{Loss} is total transmission losses. The transmission losses PLoss can be calculated by using B matrix technique and is defined by as,

$$P_{loss} = \sum_{i=1}^n \sum_{j=1}^n P_i B_{ij} P_j \quad (6)$$

Where B_{ij} ,s are the elements of loss coefficient matrix **B** (Transmission losses).

V. PROPOSED GENERAL ALGEBRAIC MODELING SYSTEM (GAMS)

The General Algebraic Modeling System (GAMS) is specifically designed for modeling linear, nonlinear and mixed integer optimization problems. The system is particularly very advantageous with large, complex problems. GAMS module allows the user to concentrate on the modeling problem by making the setup simple. GAMS are especially useful for handling large, complex, one-of-a-kind problems which may require many revisions to establish an accurate model. The user can change the formulation quickly and easily, and can even change from one solver to another [17-18].

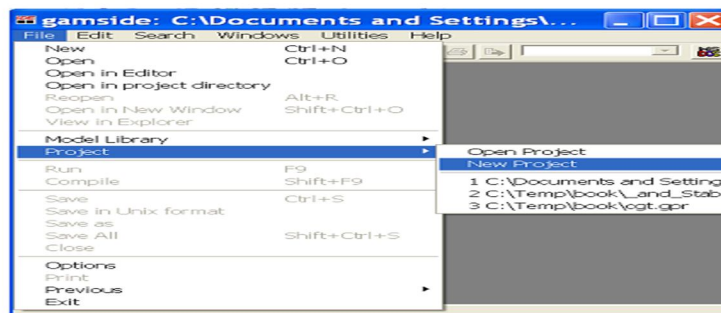


Fig 3 min window of General Algebraic Modeling System

Show Fig 3 min window of General Algebraic Modeling System. There are Six Types Model Libraries Used In GAMS, Model Library, GAMS Test Library, GAMS Data Utilities, EMP Library, API Library and Practical Financial Option Model.

VI. THE STRUCTURE OF GAMS PROGRAMMING

The basic structure of a mathematical model coded in GAMS has the components: sets, data, variable, equation, model and output show in given Fig.4. In general, any optimization problem can be formulated using these components. The data presentation in GAMS can be done in its most elemental form using tables, columns etc 19].

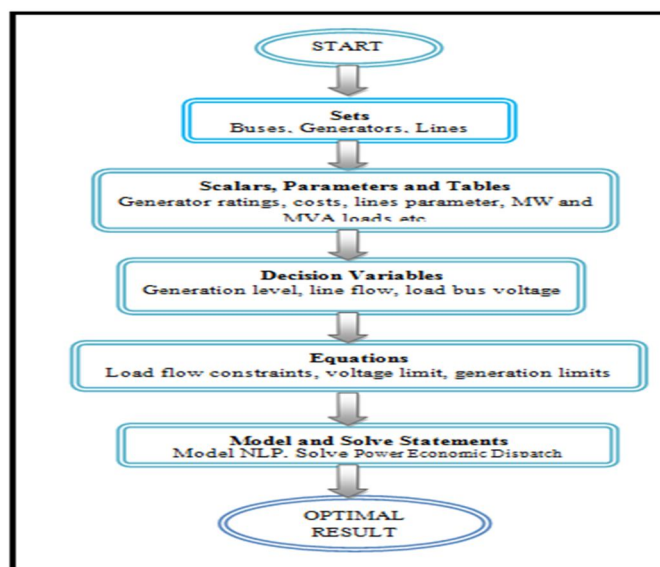


Fig 4 the structure of GAMS programming

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VII. RESULTS ANALYSIS WITH CASE STUDY

Test Case (A) Comparative case study 3 units

Table 1 and table 2 are provides a comparison of Power economic load dispatch results classical GAMS and Lambda Iteration Method for a 3 unit thermal system without loss and with loss. In this case study different load **120 MW, 150 MW and 170 MW**, these results show improvement in the solution of the problem while satisfying all the constraints. It can be seen that classical GAMS is computationally quite efficient to compare with Lambda methods with both the case without loss and with loss. Hence, the proposed method improves the results.

Table 1 Results of Three Unit System (Without Loss)

Classical methods	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method
Pg1 MW	22.0625	22.042	31.9375	31.937	38.5625	38.534
Pg2 MW	58.5	58.482	67.2778	67.277	73.1667	73.141
Pg3 MW	39.5	39.476	50.7857	50.785	58.3571	58.325
Power load MW	120	120	150	150	170	170
Thermal power plant Fuel Cost (\$/hr)	1357.2	1356.744	1579.71	1579.699	1731.63	1730.974

Table 2: Results of Three Unit System (With Loss)

Classical methods	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method
Pg1 MW	22.9577	22.050	32.8204	31.945	39.4269	38.541
Pg2 MW	55.7822	58.451	64.6008	67.247	70.5116	73.111
Pg3 MW	42.8176	39.514	54.9443	50.832	63.0889	58.377
Power load MW	120	120	150	150	170	170
Power loss	1.52698	0.015	2.34274	0.023	2.99255	0.029
Thermal power plant Fuel Cost (\$/hr)	1368.35	1356.857	1597.66	1579.873	1754.26	1731.199

Test Case (B) Comparative case study 6 units

Table 3 and table 4 are provides a comparison of Power economic load dispatch results classical GAMS and Lambda Iteration Method for a 3 unit thermal system without loss and with loss. In this case study different load **600 MW, 800 MW, 1000MW, 1263 MW and 1450 MW**, these results show improvement in the solution of the problem while satisfying all the constraints. It can be seen that classical GAMS is computationally quite efficient to compare with Lambda methods with both the case without loss and with loss. Hence, the proposed method improves the results.

Table 3 Results of 6 Unit Systems (Without Loss)

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Classical methods	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method
Pg1 MW	271.879	271.875	342.221	342.215	391.664	391.659	446.707	446.707	485.664	485.668
Pg2 MW	50	50.000	94.2684	94.264	130.7	130.696	171.258	171.258	199.963	199.966
Pg3 MW	128.128	128.125	182.839	182.834	221.294	221.291	264.106	264.106	294.406	294.409
Pg4 MW	50	50.000	50	50.000	82.4056	82.402	125.217	125.217	150	150.000
Pg5 MW	50	50.000	80.6937	80.688	123.956	123.952	172.119	172.119	200	200.000
Pg6 MW	50	50.000	50	50.000	50	50.000	83.5933	83.593	119.953	119.957
Power load MW	600	600	800	800	1000	1000	1263	1263	1450	1450
Thermal power plant Fuel Cost (\$/hr)	7187.41	7187.344	9458.09	9457.827	11887.30	11887.017	15275.99	15275.930	17802.96	17802.793

Table 4: Results of 6 Unit Systems (With Loss)

Classical methods	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method	Lambda Iteration [20]	GAMS method
Pg1 MW	273.436	271.890	341.757	341.730	391.011	391.654	447.122	446.713	496.776	485.732
Pg2 MW	50.000	50.000	95.2846	95.265	131.737	130.707	173.22	171.279	200	200.000
Pg3 MW	129.552	128.139	182.325	182.306	220.404	221.282	263.962	264.105	300	294.454
Pg4 MW	50.000	50.000	53.5857	53.565	93.3534	82.514	139.093	125.358	150	150.000
Pg5 MW	50.000	50.000	82.5827	82.562	121.621	123.924	165.617	172.040	200	200.000
Pg6 MW	50.000	50.000	50	50.000	50	50.000	86.6583	83.630	120	119.977
Power load MW	600	600	800	800	1000	1000	1000	1263	1450	1450
Power loss	2.98958	0.030	5.43591	5.428	8.0945	0.081	12.4204	0.125	16.7313	0.163
Thermal power plant Fuel Cost (\$/hr)	7220.73	7187.663	9523.64	9522.377	11989.60	11888.033	15446.1	15277.585	18035.4	17805.050

VII. CONCLUSION

Power Economic dispatch problem being attempted using classical GAMS method for 3 and 6 generator test system evaluates the performance of the proposed approach. The solution results are high accuracy and fast computational time. Therefore, this results shows that proposed GAMS optimization is a promising technique for solving complicated problems in power system.

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