Bid based Power Flow for Practical Utility System

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ABSTRACT

To meet the growing load demand and provide reliable power supply, competition is introduced in the operation of electrical power market. In this scenario, the generators are submitting their energy bids in different time blocks. The market power for the corresponding load demand is determined from the submitted generators bids. In this paper, the total production cost for the corresponding load demand is determined from the generators bids and the corresponding power flow is demonstrated on 26 bus practical utility system. The obtained results proved that the proposed method is effective in the determining the generator operating settings from their submitted bids for the corresponding load demand.

Key Words- Competitive environment, Bids, Market power, Load demand.

1. INTRODUCTION

Bidding is the power trading procedure in which participants offer to buy energy and bids to sell energy directly in a restructured power market. It is the better bilateral trading of energy market than the existing markets like customized long term contracts, trading over the counter. All market participants can observe the quantities and prices submitted but do not know the identity of the party that submitted each bid or offer. When a party submits a new bid, the system that executes the exchange checks to see if there is a matching offer for the period of delivery of the bid. If it finds an offer whose price is greater than or equal to the price of the bid a deal automatically struck and the price and quantity are displayed for all participants to see. If no match is found, the new bid is added to the list of outstanding bids and will remain there until a matching offer is made or the bid is withdrawn or it lapses because the market closes for that period. A K David et al [1], discuss the framing of ground rules by system operators to prevent the bad use of the market by the participants in order to achieve their maximum profit. The different methods of bidding of strategic bid, multipart bid, single part bid, iterative bid and demand side bid are also explained in this literature review. Song et al [2], describe the importance of decision maker in the bidding process and his influence in the future market. Sometimes supplier's bid affect the spot price while others bidding level affected by the market price. To achieve optimal bidding strategy Markov decision process is proposed which is discrete state and time type. Plazas et al [3], describe the need of consideration of a thermal power producer in a sequence of spot market namely day-ahead, automatic generation control (AGC) and balancing markets. A new stochastic programming methodology is proposed to determine the optimal bidding strategies for the day-ahead market. Conejo et al [4], describe the bidding strategy for price taker under price uncertainty in a pool-based electricity energy

market also a modal has been proposed based the probability density functions of forecast prices. Bompared et al [5] explore the supply side strategic bidding in competitive electricity markets with network constraints impacts and demonstrated on IEEE 30 bus systems used as test system with perfect competition and strategic bidding techniques. A comprehensive approach has been used for modeling strategic bidding behavior under network constraints in a pool-based system. Analytical and numerical tools were used for assessing the impact of the constraints. Fututome et al [6] address the bidding market based on single price auction model with Ac network constraints for maximizing social surplus i.e. total profit of sellers and buyers. A standard IEEEJ WEST 30 test system was used with spot loads belonging to spot market and non spot loads such as bilaterally contracted customers and local utility supplied customers at the same time. In the papers [7&8], the bidding strategy of a system is determined with inadequate information between the competitors in a multi trading market is solved by Watkins's reinforcement learning method. Many researchers [9-12], describe the leadership, the company with large generating capacity and low generating cost is named as leadership- Company and it may concentrate on gaining of additional profit. So market will be less efficient and it influences the optimal bidding strategies. Market power is the ability of a particular seller or group of sellers to maintain the price profitably above competitive level for the significant period of time. Overbye et al [13], give a brief idea about the prediction strategy of the market power in real time power systems.

In this paper, the total production cost for a particular load demand is computed from the optimized generator bids. The power flow is carried out by satisfying the transmission constraints. The validity of the proposed work is tested in 26 bus practical utility system.

2. PROBLEM FORMULATION

The minimum value of the generation production cost C_t is determined by the equation (1).

$$\text{Minimize } C_t = \sum_{i=1}^{N_g} C_i \qquad (1)$$

C_t -Total bidding cost of generation (Rs/hr).

C_i -Bidding cost of ith generator.

N_g -Number of generators.

The above objective function satisfies the following constraints. The power balance equation is given by

$$g\ |v|, \theta\ = 0 \qquad (2)$$

Where

$$g\left(|v|,\theta\right) = \begin{vmatrix} P_i\left(|v|,\theta\right) - P_i^{net} \\ Q_i\left(|v|,\theta\right) - Q_i^{net} \\ P_m\left(|v|,\theta\right) - P_i^{net} \end{vmatrix} \tag{3}$$

P_i & Q_i → Calculated real and reactive power
      for PQ bus i.

P_i^{net} & Q_i^{net} → Specified real and reactive power
      for PQ bus i.

P_m & P_m^{net} → Calculated and specified real
      power for PV bus m.

$|v|$ & θ → Voltage magnitude and phase angle
      of different buses.

$\left.\begin{array}{l} P_i\left(|v|,\theta\right) - P_i^{net} \\ Q_i\left(|v|,\theta\right) - Q_i^{net} \end{array}\right\}$ →For each PQ bus i.

$P_m\left(|v|,\theta\right) - P_i^{net}$ →For each PV bus m, not including
      the reference bus.

- The inequality constraint on real power generation P_{gi} of each generation

$$P_{gi}^{min} \le P_{gi} \le P_{gi}^{max} \tag{4}$$

P_{gi}^{min} & P_{gi}^{max} →Minimum and maximum value of real
      power allowed at generator i.

- The inequality constraint on voltage of each PQ bus i

$$V_t^{min} \le V_t \le V_t^{max} \tag{5}$$

V_t^{min} & V_t^{max} →Minimum and maximum voltage at
      bus i.

- Power limit on transmission line

$$MVAf_{p,q} \le MVAf_{p,q}^{max} \tag{6}$$

$MVAf_{p,q}^{max}$ → Maximum rating of transmission line
      connecting bus PQ.

3. STEP – BY – STEP ALGORITHM

The proposed algorithm to determine the production cost of generators from their bids is explained as follows.

- Obtain the bidding data of the corresponding generators in each block.
- Sketch the consolidated bidding curve of the generators obtained from the optimized bidding data in each block. This gives an overall idea about the contribution of generators in each block of load demand of the above generators.
- Obtain the generators settings for the different load demand from the above bidding curve.
- Obtain the power solution of the above generators setting by satisfying the transmission line constraints.
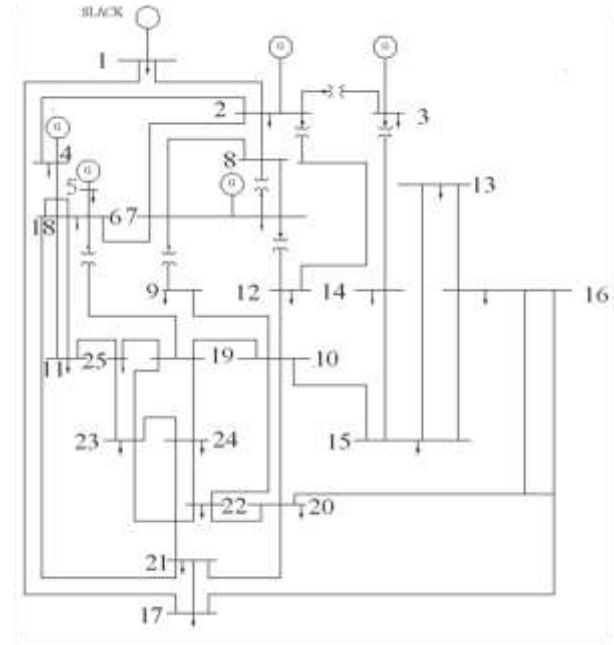- Compute the total production cost for the different case studies.
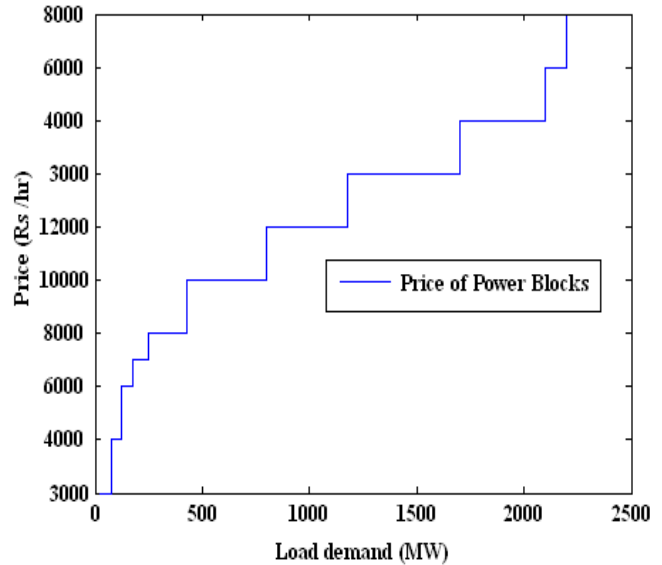

Figure 1. One line diagram – 26 Bus System

Figure 2. Bidding Curve of Generators

4. SIMULATION RESULTS AND DISCUSSION

The bid based optimal generation cost is computed by executing the bid based power flow algorithm in the MATLAB environment. The proposed methodology was demonstrated on the practical 26 bus utility system [14]. Its one line diagram is given in Fig.1. It consists of 6 generators, 46 numbers of 220 KV transmission lines and 7 tap changing transformer. The generator settings are obtained from the bidding blocks of the corresponding generators for a particular load demand. The power flows in the transmission lines are computed using Newton Rahpson method. The bidding based power flow solution is

demonstrated on the above utility system with the following case studies.

1. Base load condition
2. Increased in load condition
3. Critical load condition

Case study 1: Base load condition

The 26 bus utility system is subjected to the base load demand of 1000 MW. The bidding data of the each generator are given in Appendix. The bidding curve is formulated by arranging the optimized bids of corresponding generator in each block .The generators settings for the base load condition are obtained from the submitted generator bids and same is illustrated in Fig.2. The load flow solution for the test system is obtained using the above generator settings for the base load demand.

Case study 2: Increased in load condition

To illustrate the efficiency the proposed methodology, the load demand of the test system is increased to 1800 MW and the corresponding power flow solution is obtained using the respective generator contribution as given in Fig.2. The obtained power flow solutions satisfy the thermal limit of the transmission lines as illustrated in Fig.3.

Case study 3: Critical load condition

There is an ambiguity in the computation of cost when the bids are switched from one block state to another as given in Fig.2. The load demand at this switched state is termed as critical load in this work. In this critical load condition, the bidding cost of the committed generators are taken as the half the values in the corresponding blocks. The production cost is computed by taking the above optimized price approach. The production cost of each generator for the above case studies is given in the Fig. 4. The consolidated bid based generator's settings and the production cost for above three case studies is given in Table 1.

5. CONCLUSIONS

The paper demonstrated the generator bid based power flow solution of a practical utility system with different case studies. The obtained solution gives over all idea about the computation of production cost from the generator bids of the competitive environment. It also illustrates the computation of production cost when the generator bids shift from one block to another. The power flow solution is obtained by Newton Raphson method by satisfying the constraints. In a nutshell, this paper gives knowledge about the prediction of total production cost of the system form the bidding structure of generators for the corresponding load demand.
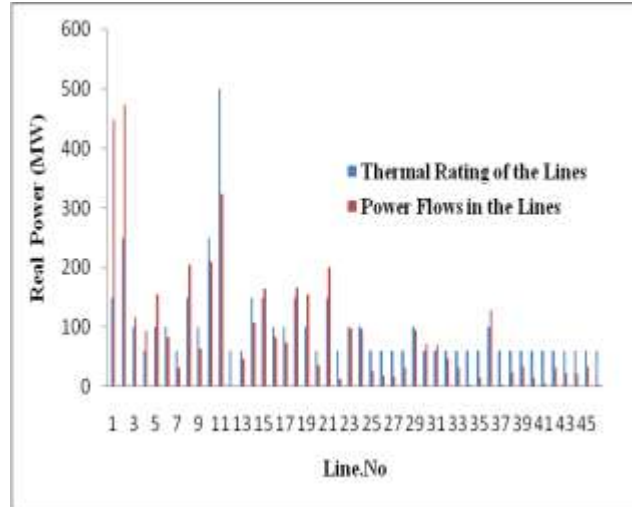

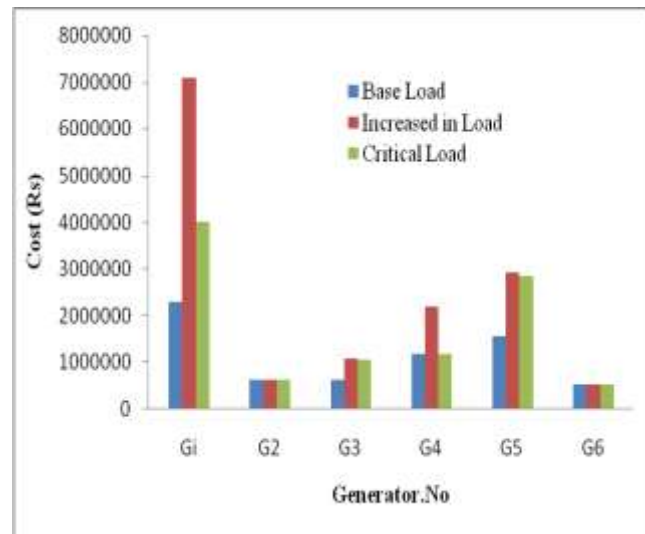
Figure 3. Power flows in the transmission lines

Figure 4. Total Production Cost

Table 1. Power dispatch Solutions for different case studies

Load Demand	Contribution of Generators (MW)						Total Cost (Rs/hr)	Total Loss (MW)
	G_1	G_2	G_3	G_4	G_5	G_6		
Base load	300	100	100	200	225	75	6837500	7.960
Increased in load	800	100	150	300	375	75	14437500	27.213
Critical load	500	100	150	200	375	75	10237500	15.296

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BIOGRAPHIES

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APPENDIX

BIDDING DATA OF THE GENERATORS

Generator G_1 (100-1000 MW)		
Block	Quantity (MW)	Cost (Rs/MW)
0-100	100	7000
100-300	200	8000
300-500	200	9000
500-800	300	10000
800-1000	200	11000

Generator G_4 (0-300MW)		
Block	Quantity (MW)	Cost (Rs/MW)
0-50	50	4000
50-75	25	5500
75-150	75	6000
150-200	50	8000
200-300	100	10000

Generator G_2 (0-100MW)		
Block	Quantity (MW)	Cost (Rs/MW)
0-50	50	5000
50-75	25	7000
75-100	25	8000

Generator G_5 (0-600MW)		
Block	Quantity (MW)	Cost (Rs/MW)
0-75	75	6000
75-175	100	7000
175-250	75	8000
250-400	150	9000
400-500	100	10000
500-600	100	12000

Generator G_3 (0-150MW)		
Block	Quantity (MW)	Cost (Rs/MW)
0-25	25	3000
25-75	50	7000
75-100	25	8000
100-150	50	9000

Generator G_6 (0-75MW)		
Block	Quantity (MW)	Cost (Rs/MW)
0-25	25	5000
25-50	25	7000
50-75	25	9000