iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** XI **Month of publication:** November 2022

DOI: https://doi.org/10.22214/ijraset.2022.47759

Congestion Management in Deregulated Power System Using Different Control Technique

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Abstract: In today's scenario there is a challenge for power companies to meet the expected demand load due to continuous increases in load demand causes unpredictable failure in the components of power system including transmission line, generator, transformer and various other equipment this leads to over loading in the power system and the line become congested if this failure not removed on time the system reaches to emergency state, therefore we are using various techniques to control or manage these situations these methods includes Generator Rescheduling(GR),Load Shedding, Particle Swarm Optimizer(PSO), Grey Wolf Optimization (GWO),Harmony search algorithm etc. Optimal load shedding is effective control action for congestion management. The various algorithm applied on IEEE 30 bus system.
Keywords: Optimal load shedding, congestion management, contingency analysis

I. INTRODUCTION

A power system comprises of three kinds of units - (1) generation (2) transmission (3) distribution. With these three unit of operation and working the power system becomes complicated and complex and depends on condition of existing technology as well as on other factors economy, social advancement and various environmental impacts.

A deregulated power system market allow the market competitors to sell and purchase power by investing in power plant and transmission line .This is a three step process, the GENCO (generation companies) offer electricity to retailers the retailers further set it for customers according to costumer cost[1]. It become beneficial for customer providing them to look at the rates and separate third party organization .The main goal of deregulated power system is to separate power production and sale of power to all network .The deregulated power system is beneficial for customers because it provide the minimum cost due to competition among the different GENCO companies

Due to less effective functioning of newly joined companies, it goes to deregulation by isolating its operation into three separate service station i.e .generation companies, transmission companies and distribution companies. In this scenario the generation companies became more accountable for transferring the power to loads. The ISO is central authority to buyers and sellers it maintain safe and dependable procedure of power industry.

Congestion management is biggest concern in modern power system these can be various reason for congestion of load that is the less supply of power system than demand so the power system gets congested,it occurs due to transformer failure, sudden breakout, equipment failure, transmission line faults, voltage instability ,deficiency of reactive power etc[2].These situations leads to exceed the constraints and operational limits causes the system become more congested over burden the limit and reaches the emergency state,so this can be control by various methods in this paper we mainly focuses on two methods (1) Optimal load shedding (2) Generation rescheduling.

[3]In optimal load shedding to control congestion the load shedding is done to reduce load at minimum level by least affecting the power system for this we use different techniques (1) Grey wolf optimization (2) Harmony search algorithm

[2]The Grey wolf optimization based on meta -heuristics algorithm ,taken from Grey wolves hunting approach and social hierarchy ,it made up of four parts-

(i) Encircling the prey (ii) hunting (iii) attacking (iv) searching

In harmony search algorithm ,the transmission line load can be physically removed and electricity cost can be made equal [4]-[5].

Load remove should be optimal and the effect of removal determined by using sensitivity factor based on dc power flow model .The improved harmony can improve power system security to avoid voltage downfall.

[7]-[8]The second method to control over congested load is Generator Rescheduling ,for this we find out the generator rescheduling factor (GSF) which help in deciding the decreasing order of generator using the PDF (power distributing factor),

this method can reduce the greater burden on slack bus in which any change in active power transmission line automatically changes all the other regions.

In G.R. there are several algorithm methods used PDF firefly algorithm generator, power generator rescheduling based on cuckoo search algorithm, power generator rescheduling based on firefly algorithm[5]-[6].

The main aim of congestion management is to keep the system stable and within its limit ,for this assessment should be done to know the limits when lines gets congested.

II. ASSESSMENT OF CONGESTION PROBLEM

For assessment management in congested line the apparent power before and after should be compared .consider the transmission line k that connect the buses i and j .for finding out the apparent power on transmission line k .

$$S_K = \sqrt{P_K^2 + Q_K^2} \quad (2.1)$$

The reactive power for congested line is represented as follows

$$S_{Kc} = \sqrt{P_{Kc}^2 + Q_{Kc}^2} \quad (2.1)$$

Maximum power for any congested line is shown as

S_{max}. the ratio of transmission power occurs after congestion to the maximum power is greater than one .then the power system is congested. And if it is less than one then in its safe limits.

III. METHODS FOR CONGESTION MANAGEMENT

Congestion management is method of using technical and non technical techniques .the technical techniques includes FACTS, phase shifter, transformer etc. Which doesn't cause any economic loss. The non technical approach includes nodal pricing ,generator rescheduling, demand response, distributed generator.

IV. CONGESTION MANAGEMENT USING GENERATOR RESCHEDULING

Two methods of congestion management have been applied

(i) GSF based (ii) Zonal pricing based

In GSF based congestion management ,those generators are affected whose generation affect the congested line flow the Sensitivity factor helps in determining the rank and the affected Generator .

In zonal pricing ,the zones are selected according to the places where

Little congestion within the zone so instead of all the path the crossed zone is congested and priced. To reduce congestion the power transfer between the zones should matched the limits .every zone is distributed in its locational marginal price (LMP).

V. PROBLEM FORMULATION FOR CONGESTION MANAGEMENT

A. Determining The Generator Sensitivities

Once the congestion line is identified generator rescheduling is offered as a method to reduce system congestion .A change in real power in transmission line k connected between the line i and j as the result of change in power generation of generator g is defined as generator sensitivity of congested line GSF_g

$$GFS_g = \frac{\Delta P_{ij}}{\Delta P_{G_g}} \quad (5.1)$$

The GSF showing the real power flow between the generators

And transmission line i and j and help to find out the congested line and generator sensitives.generation rescheduling is done to restore the active power in the system by technical means.The amount of rescheduling is calculated by the formulas -

$$\textit{Minimize congestion cost: } C_c = \sum_{k \in N_g} (C_k \, \Delta P_{Gk}^{+} + D_k \Delta P_{Gk}^{-}) \quad (5.2)$$

Where,

$Generators'\ incremental\ and\ decremented\ price\ bids\ are\ C_k C_k$ and D_k

ΔP_{Gk}^{+} and ΔP_{Gk}^{-} are the real power adjustments in output of participating generators.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XI Nov 2022- Available at www.ijraset.com

1) Equality Constraints

The power flow equations are represented by CM's equality constraints as follows::

$P_{GK} - P_{DK} = |V_j||V_k||Y_{kj}|\cos(\delta_k - \delta_j - \theta_{kj})$ j=1, 2, ………., N_b (5.3)

$Q_{Gk} - Q_{Dk} = |V_j||V_k||Y_{kj}|\sin(\delta_k - \delta_j - \theta_{kj})$

j=1, 2, …………N_b (5.4)

$P_{Gk} = P_{Gk}^C + \Delta P_{Gk}^+ - \Delta P_{Gk}^-$

k=1, 2, …………N_g (5.5)

$P_{Dj} = P_{Dj}^C$ j=1,2, ……………N_d (5.6)

Equations (5.3) and (5.4) depict actual and reactive power balance at each node, whereas (5.5) and (5.6) depict final power as a function of market clearing price.

Notations	Description
P_{Dk} and Q_{Dk}	At bus k, the real and reactive load power
$P_{Gk}$and Q_{Gk}	At bus k, actual and reactive power were generated.
$V_j$and V_k	Bus j and k voltages
δ_j and δ_k	The j and k bus voltage angles
θ_{kj}	Angle of admittance of the line connecting k and j
N_b, N_g, and N_d	Buses, generators, and load numbers
P_{GK}^C and P_{DJ}^C	Generator k produces actual power, whereas load bus j consumes real power.
P_{Gk}^{min} and Q_{Gk}^{min}	Real and reactive power minimum values at bus k
P_{Gk}^{max} and Q_{Gk}^{max}	Real and reactive power maximum values at bus k
V_n^{min} and V_n^{max}	Voltage's minimum and maximum values
N_l	Number of lines

2) Inequality Constraints

All transmission lines, transformers, and generators have operating and physical restrictions are represented by the inequality constraints..

$P_{Gk}^{min} \le P_{Gk} \le P_{Gk}^{max}, kN_g$ (5.8)

$Q_{Gk}^{min} \le Q_{Gk} \le Q_{Gk}^{max}, \quad \forall k \quad \forall \quad N_g$ (5.9)

$(P_{Gk} - P_{Gk}^{min}) = \Delta\ P_{Gk}^{min} \le \Delta P_{Gk} \le \Delta\ P_{Gk}^{max} = (P_{Gk}^{max} - P_{Gk})$ (5.10)

$V_n^{min} \le V_n \le V_n^{max}, \quad \forall n \quad \forall \quad N_l$ (5.11)

$P_{ij} \le P_{ij}^{max}$ (5.12)

B. Determination Of Participating Generators Using Zonal Pricing

It includes the zonal pricing required to help clearing the real time market zone compared by location within the zone when there is low congestion. these are based on locational marginal price (LMP) .The LMP may vary from place to place .Consider the n-bus network after the congestion has occurred the area is divided into m zones. As a result the LMP for the mth zone is determined as follows-

place .Consider the n-bus network after the congestion has occurred the area is divided into m zones.As a result the LMP for the mth zone is determined as follows-

LMP for m^{th} zone $= \frac{\sum_k^{N_b} LMP_k \times P_{Dk}}{\sum_k^{N_b} P_{Dk}}$ (5.13)

VI. RESULTS

The proposed assessment of congestion problem and control in this report are verified on IEEE-30 bus test network. The system includes six generators, 24 load buses mentioned in the Appendix. The different operating conditions are created by outage of transmission line and outage of transmission line with increasing load. Security status of the system is carried out for base loading and different congested states. For the insecure cases, generation rescheduling is also proposed..

A. No Contingency

The loads are set at base load on the buses. When using DC optimal power flow then the value of LMP is fixed for all the buses and the value LMP for all the buses is 3.789 ($/MVA-hr). At DC optimal power flow total generation capacity and on-line capacity both are 335(MW). Actual generation and actual load both are 189.2(MW). Total inter-tie flow for DC optimal power flow is 52.3(MW), losses are zero.

The loads are set at base load on the buses. When using AC optimal power flow then the value of LMP is different for all the buses. At AC optimal power flow total generation capacity and on-line capacity both are 335(MW) and -95 to 405.9(MVAr). Actual generation is 192.1(MW) and 105.1(MVAr). Actual load is 189.2(MW) and 107.2(MVAr). Total inter-tie flow is 51(MW) and 58.1(MVAr). Losses are 2.86(MW) and 13.33(MVAr)

B. Consider Outage of Line 1-2

The load we take same as base load .when using the AC optimal power the value on both the lines are same .Actual generation is 192.3(MW) and 109 (MVAr) .the total inter line flow is 51.1(MW0 and 56.3(MVAr).losses are 3.09(MW) and 14.46(MVAr).during the outage of transmission line the 1-2 there are transmission lines having more than 0.9 overloading factor,the three transmission lines are 6-8,21-22and 25-27.in this paper the transmission lines declared as congested whhen the overloading factor is above 0.9 when it is below 0.9 considerd safe and at 0.9 critical condition,.

Bus No.	Generation(MW)	LMP($/MW-hr)
1	40.07	3.603
2	56.57	3.730
3	-	3.749
4	-	3.777
5	-	3.775
6	-	3.791
7	-	3.820
8	-	5.322
9	-	3.833
10	-	3.855
11	-	3.833
12	-	3.814
13	16.29	3.814
14	-	3.872
15	-	3.860
16	-	3.855
17	-	3.870
18	-	3.917
19	-	3.933
20	-	3.917
21	-	3.861
22	22.80	3.849
23	16.32	3.816
24	-	3.885
25	-	3.922
26	-	3.988
27	40.25	3.921
28	-	4.102
29	-	3.970
30	-	4.055

Table 6.1. Details of generation and LMP values for IEEE 30-bus test system with outage of line 1-2.

Type of contingency	Congested lines	Maximum limit line power flow (MVA)	Line power flow (MVA)
Outage of line 1-2	6-8	32	31.6320
	21-22	32	31.6698
	25-27	16	15.8889

Table 6.2. Details of congested lines for IEEE 30-bus corresponding for Case-2

C. *Congestion Management With Zonal Pricing For Line 1-2*

In this case there are two zones. First one is which have more than equal to LMP value 4 and second one is less than LMP value 4. The zones are shown in Table 6.3 for case 2 with outage of transmission line 1-2.

S.No.	Zones	LMP($/MW-hr)
1	Zone1(bus no.8,28,30)	4.4933
2	Zone2(remaining 27 buses)	3.8457

Table 6.3. Zones for Case 2 (outage of transmission line 1-2)

D. *Congestion Management With Generation Sensitivities Factor For Line 1-2*

Congested line	GS(1)	GS(2)	GS(13)	GS(22)	GS(23)	GS(27)
6-8	-0.0562	0.0711	0.9344	1.5033	1.4994	0.2438
21-22	-0.0730	0.0924	1.2146	1.9541	1.9490	0.3169
25-27	0.0516	-0.0653	-0.8587	-1.3815	-1.3779	-0.2240

Table 6.4. Generator Sensitivity for Case 2 (outage of transmission line 1-2)

E. *Comparison of Proposed Congestion Management Approaches*

Table 6.5 shows the comparison of both the proposed congestion management approaches for Case 2.

Parameters	Proposed Generation Rescheduling Techniques	
	(GSF Based)	(ZP Based)
Total congestion cost ($/h)	296.79	289.98
On previously congested line 6-8, power flow (MVA)	28.16	28.48
On previously congested line 21-22, power flow (MVA)	24.32	25.92
On previously congested line 25-27, power flow (MVA)	8.42	11.68
$\Delta \boldsymbol{P_{G1}}$(MW)	0	0
$\Delta \boldsymbol{P_{G2}}$(MW)	0	0
$\Delta \boldsymbol{P_{G3}}$(MW)	7.82	4.51
$\Delta \boldsymbol{P_{G4}}$(MW)	-9.62	-5.32
$\Delta \boldsymbol{P_{G5}}$(MW)	38.43	30.45
$\Delta \boldsymbol{P_{G6}}$(MW)	0	15.75
Total Generation Rescheduled (MW)	55.87	56.03

Table 6.5 Comparison of results obtained from different techniques for IEEE 30-bus test system for Case 2.

Table 6.5 presents that congestion cost from GSF based method is 296.79($/h) and congestion cost from zonal pricing (ZP) based method is 289.98($/h). The congestion cost is less in market based ZP method as compared to GSF based method. Total amount of rescheduled real power in GSF based method is 55.87(MW) and for ZP based method is 56.03(MW). The rescheduled amount of real power is less in GSF based method. Also, the congestion is relieved from all the congested transmission lines and system is in secure condition.

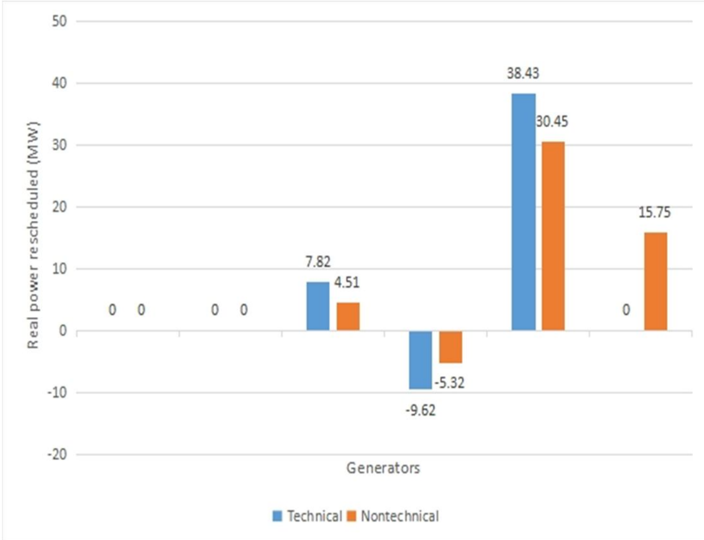

Fig 6.1 Comparison of real power rescheduling of generators for IEEE 30-bus test system for Case2.

VII. CONLUSION

These results are obtained for the standard test system for assessment of congestion problem and the control of congestion. The results are verified on the IEEE-30 bus system. Values of overloading factor and LMP for different case (different outages of line with different load conditions). The congested transmission lines identified. For these congested transmission lines generation rescheduling is applied using two different approaches, based on generator sensitivity factor (GSF) and zonal pricing (ZP). The results obtained are found to be satisfactory.

This work has proposed an optimum algorithm to obtain the optimal amount of generation rescheduling. The proposed procedure can recover the secure condition for electric system. From result, it is found that zonal pricing (ZP) method for congestion management is market-based method. Therefore, this method has less congestion cost as compared to GSF based method and the amount of real power rescheduled can be higher or lower for any method.

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