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Congestion Management in Deregulated Power System – A Review

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Abstract: ***Congestion in the transmission lines is one of the most important issues for secure and reliable power system operations that appear in the deregulated environment. The congestion occurs when the total load of electric power causes the transmission system to operate beyond maximum transfer limits. To relieve congestion in transmission lines, there are two types of congestion management methodologies. One is cost-free methods and another is non-cost free methods, among them first method relieves the congestion technically whereas the other related more with the economics. In this paper, different cost-free methodologies were used to manage the congestion in the transmission network.***

Keywords: Congestion Management, optimal power flow (OPF), Multi-objective optimization, Available Transfer Capability (ATC), Thyristor-controlled series capacitor (TCSC).

1. Introduction

Restructured power system has entities like Genco, Transco, Disco, Independent system operator (ISO). The ISO is an entity with the responsibility of ensuring the security and reliability of entire system. Transmission lines are often driven close to or even beyond their thermal limits in order to satisfy the increased power demand and trades due to increase of the uncontracted power exchanges. If the contract were not controlled, some lines located on particular paths may become overloaded; this phenomenon is called congestion. The transmission network with growing concerns of environment and pressure for effective use of existing facilities in competitive electricity market, environment can cause to violate the physical limits of transmission system more frequently to carry more power which leads to the congestion.

The restructured power system has more benefits so that it is quite popular in now days. This paper presents a new method to mitigate congestion in a restructured Power system. The Increased power demand has forced the system to operate very closer to its stability limits, So Transmission congestion, power loss problems and Voltage instability are arise in the power system. These are very serious problems which cause damage to the power system. Congestion is a tough task in Restructured power system. This congestion in the network may hamper market efficiency, forcing the customers to back down power consumption due to rise in electricity prices and may threaten security of the power system, making system to lower stability margins. Transmission line congestion initiates the cascading tripping of transmission line which forces the system to collapse. Accurate prediction and alleviation of transmission line overloads is the suitable corrective action to avoid transmission line tripping. Thus, it is the duty of the ISO to mitigate congestion utilizing different techniques may be cost free or cost based.

Congestion could prevent system operators from dispatching additional power from a particular generator. Congestion could be caused by various reasons, such as generator outages, transmission line outages, and changes in energy demand and uncoordinated transactions. Congestion may result in preventing new contracts, infeasibility in existing and new contracts, additional outages, and monopoly of prices in some regions of restructured power systems and may damages to system components. Congestion may be prevented to some extent by means of reservations, rights and congestion pricing. Congestion is a term that has come to power systems from economics in conjunction with deregulation, although congestion was present in power systems before deregulation. There it was discussed in terms of steady-state security, and the basic objective was to control generator output so that the system remained secure at the lowest cost. When dealing with power flow within its operating area, one entity, the vertically integrated utility(VIU), controlled both generation and transmission, gained economically from lower generation costs, and was responsible or the consequences and expected costs when less secure operation resulted in power outages. Conflicts between security and economics could be traded off within one decision-making entity.

There are two broad paradigms that may be employed for congestion management.

A. Cost-free means

(I) Out-aging of congested transmission lines.
(II) Operation of transformer taps changer or phase shifters.
(III) Operation of FACTS controller particularly series devices.

B. Non-cost-free means:

(I) Re-dispatch of power generation in a manner different from the natural settling point of the market. Some generators back down while others increase their output. The effect of this is that generators no longer operate at equal incremental costs.
(II) Curtailment of demands and the exercise of (not-cost free) load interruption options.
Among the above two main techniques cost-free means have the advantages like it is not going to affect economic matters, so to relieve the congestion GENCOs and DISCOs

will not come into picture. [1]

2. Literature review

2.1 Using FACTS Controllers

Thyristor-controlled series capacitor is a capacitive reactance compensator, which consists of a series capacitor bank shunted by a Thyristor controlled reactor in order to provide a smoothly variable series capacitive reactance. TCSC in normal operating range is mainly capacitive, but it can also be used in an inductive mode. The power flow in a transmission line can be increased by controlled series compensation with minimum risk of sub synchronous resonance (SSR). CSC is a second generation FACTS controller, which controls the impedance of the line in which it is connected by varying the firing angle of the Thyristor. In a TCSC, a metal oxide varistor along with a bypass breaker is connected in parallel to the fixed capacitor for overvoltage protection.

Flexible alternative current transmission system (FACTS) can be used to improve the maximum loading of transmission line by injecting the reactive power which reduces the power flow in the line, resulting in low power loss and improved stability of the system. In deregulated power systems, feasibility of transmission network components is required to be determined. It can be evaluated by ATC of the network for various applied power transactions. ATC is an important term in deregulated power system that considered in the planning and controlling of transmission infrastructure. The FACTS devices are used to enhance Available Transfer Capability in deregulated environment. Main constraints for Available Transfer Capability are steady state stability limits, voltage limits, and thermal limits. The variable load is considered as data to calculate ATC of network.

Genetic algorithm (GA) is essentially a population based search algorithm. The power of this algorithm comes from its ability to exploit historical information structures from previous solution guesses in an attempt to increase performance of future solution structures. The use of floating-point numbers in the GA representation has a number of advantages over binary encoding. The efficiency of the GA gets increased as there is no need to convert the solution variables to the binary type. Furthermore, there is greater freedom to use different genetic operators. The A typical Genetic algorithm has three phases, i.e., initialization, evaluation and genetic operations, which are consisted of reproduction, recombination or crossover and mutation.

[S. SURENDER REDDY , M. SAILAJA KUMARI, AND M. SYDULU, 2009] In the present study the authors have analyzed Genetic Algorithm for single objective and multi-objective optimization approaches for optimal location, choice and size of Thyristor Controlled Series Capacitors (TCSC) and Static Var Compensators (SVC) in deregulated power system to improve voltage stability and reduce line losses thus minimize congestion. The developed algorithms are tested on IEEE 30 bus system. Various cases like i) line outage ii) uniform line loading iii) bilateral and multilateral transactions between source and sink. Hence result gives simultaneous optimization of three objectives considered presents optimal location of FACTS devices, which reduce transmission line congestion, reduce system losses and improves system voltage profile. The proposed GA with TCSC, SVC models evolves as a good optimization algorithm for single objective optimization and SPEA for multi-objective optimization studies of optimal location of FACTS controllers' problem. [2]

[S. THANGALAKSHMI, P. VALSALAL, 2013] In this study authors have used Hybrid Fish Bee Swarm Optimization based algorithm to manage congestion is proposed to achieve this objective. The Fish Bee Swarm Optimization is based on two algorithms namely Fish School Search (FSS) and Artificial Bee Colony (ABC) methods. The proposed algorithm is validated on an IEEE 30 bus system. Results show the performance of the proposed optimization technique decreases congestion. [3]

[SMT. USHASURENDRA AND S.S. PARATHASARTHY, 2012] In this paper author study the algorithm to relieve congestion by optimally locating a Thyristor controlled series capacitor (TCSC) in a transmission line. A line utilization factor (LUF) is used to obtain the level of congestion in the transmission line. In the presence of TCSC, at the individual load points Sensitivity parameters for the total system losses are derived as a function of the real power. A fuzzy logic controller is proposed to control active power flow for congestion management. The proposed algorithm is tested successfully on the IEEE 14-bus system. The fuzzy based results are compared with the solution given by sensitivity method. Hence result shows fuzzy method is an alternative means of dealing with congestion and can be applied easily to any number of buses to relieve congestion in a power system. [4]

[G. VINOD KUMAR, J. SRINIVASA RAO, J. AMARNATH, 2013] In this paper author analyses two different types of approaches to manage the congestion in the network. The first methodology is using series FACTS device and the second method is by changing participation factors of generators. The method of Mitigation of total system VAR power loss is used to allocate the Thyristor controlled series capacitor in optimal location and transmission load relief method is used to find load curtailed bus for congestion relief in the network. From the results, it can be observed that the maximum load that can be applied to a particular bus also there is no causing of network congestion because of changing generator participation factors. So generator participation factors are also used as one of tool for management of congestion in the network. [5]

[KANWARDEEP SINGH, VINOD K. YADAV, ARVIND DHINGRA, 2012] In this paper author study the optimal location of TCSCs based on maximization of social welfare and minimization of usage cost of TCSCs. The proposed problem of optimal allocation takes the form of Mixed Integer Nonlinear Programming (MINLP) problem of convex nature and is solved by a combinatorial programming method. The proposed technique is able to handle a number of potential scenarios by assigning weights to objective

functions of individual scenarios. The effectiveness of the proposed methodology is tested on a 5-bus and IEEE 14-bus systems. Hence result shows the comparison of proposed approach with existing approaches reveal that highest improvement in social welfare is obtained by placing TCSCs in the locations as suggested by this method. [6]

[ELANGO.K, PARANJOTHI.S.R, 2011] In this paper author analyses the use of FACTS devices and Load Shedding for relieving congestion by Extended Quadratic Interior Point (EQIP) based OPF. The OPF problem is solved with the help of Evolutionary Programming (EP) approach and at major iteration, an approximation is made of the Hessian of the Lagrangian function using a Quasi Newton updating method so that the social welfare is maximized while satisfying the operation and security related constraints. The proposed algorithm has been analyzed on IEEE 57 bus system. The reactive power rescheduling and FACTS devices causes lower cost of rescheduling and the better voltage profile. The amount of reactive power supplied by the capacitor is less when it is compared to the capacitor reactive support. The proposed method gives the better results compared to the other methods. [7]

[DHANASEKAR.P, DR.K.ELANGO, May-2013] In this paper author study the particle swarm optimization (PSO) based algorithm to perform congestion management by proper placement and sizing of unified power flow controller (UPFC). The costs associated with congestion and voltage profile improvement are also included in the OF. The suggested algorithm is applied to the 5- bus test system. A PSO technique has been successfully applied to the problem. Result shows alleviation of congestion is considered as the optimization criterion. [8]

[SUJATHA BALARAMAN, N.KAMARAJ, 2010] In the present study the authors have analyzed the efficient method to find the optimal generation rescheduling for congestion management in deregulated environment using real coded genetic algorithm (RCGA). The effectiveness of the proposed algorithm has been analyzed on IEEE 30 bus test system. Contingency analysis is carried out to identify the most severe lines and those lines are considered for analysis. The proposed problem is formulated as an optimization problem having large number of constraints. Real coded genetic algorithm (RCGA) is used as optimization tool since it is an efficient heuristic algorithm for search and optimization. It operates on floating point representation of variables to be optimized. In order to prove the effectiveness of the algorithm it is compared with SA. The simulation results proved that the RCGA yield economical solution than SA for all the test cases thereby enhances system security.[I]

[N. SAMBASIVARAO, J. AMARNATH, V. PURNACHANDRARAO, Nov-2013] In this paper author analyses the best location for TCSC using priority list to have minimum total congestion rent and minimum total generation cost. Optimal Power flow (OPF) has been used to calculate generation dispatch and load schedules to obtain locational marginal pricing (LMP) and to manage congestion in the transmission systems. It is based on the bids submitted by the generators and loads and the network data. The overall objective function is to maximize the social welfare. The Simulation results were successfully tested on modified IEEE 9 bus system using Power world simulator 11.0. OPF is carried out when TCSC is placed on each line one at a time and best locations for minimum congestion rent and minimum generation cost is observed from the above tables it is observed that by using priority table, depending on the criteria of requirement, we can capture the best location of TCSC.[J]

[JAGABONDHU HAZRA AND AVINASH K. SINHA, Nov-2007] In this paper author study a realistic frequency and voltage dependent modified fast decoupled load flow method is used with multiobjective PSO technique to solve complex problem. The proposed algorithm is tested on IEEE 30-bus system, IEEE 118-bus system, and Northern Region Electricity Board, India (NREB) 390-bus system. Multiobjective PSO does not guarantee global optimal solution; it provides a very close suboptimal solution for smooth as well as non-smooth objective functions. This method also provides a set of pareto optimal solutions for any congestion problem, giving the system operator options for judicious decision in solving the congestion.

3. Conclusion

For secure operation of electrical power system, the transmission network loading has to be maintained within specified limits. Transmission line congestion initiates the cascading tripping which force the system to collapse. The generators which are participating in congestion alleviation based on the congested line. They have been used for corrective rescheduling and minimizing the FATCS devices to alleviate congestion. The reactive power rescheduling and FACTS devices causes lower cost of rescheduling and the better voltage profile. It is noted that the minimum cost of rescheduling is observed when the generator and capacitor provide reactive support. The proposed method gives the better results compared to the other methods.

4. Future Work

The complex search algorithms are implemented for location of TCSC as these devices are already in operation. This approach can be extended to other FACTS devices also as they can shift the attitude from ‘preventive’ approach requiring large standbys for emergency purpose to a ‘corrective’ approach by creating instant corrections with fewer versatile, controllable and manageable devices. In this paper voltage constrained transfer capability is discussed and the future work could implement the other constraints like thermal and economic considerations.

References

[1] P.Suganya, S. Nandini, Mrs. K. Muthulakshmi, “Congestion Management Using UPFC in Deregulated Power System,” International Journal of Innovative Research in Science, Engineering and Technology, Volume 3, Special Issue 1, pp. 700-705, 2014.

[2] S. Surender Reddy, M. Sailaja Kumari and M. Sydulu, "Congestion Management in Deregulated Power System by Optimal Choice and Allocation of FACTS Controllers Using Multi-Objective Genetic Algorithm," Journal of Electrical Engineering & Technology Vol. 4, No. 4, pp.467-475, 2009.
[3] S. Thangalakshmi, p. Valsalal, "Congestion management using hybrid fish bee optimization," Journal of Theoretical and Applied Information Technology, Vol. 58 No.2, pp. 405-412, 2013.
[4] Smt. Ushasurendra and S. S. Parathasarthy, "Congestion management in deregulated power sector using fuzzy based optimal location technique for series flexible alternative current transmission system (FACTS) device," Journal of Electrical and Electronics Engineering Research Vol. 4(1), pp. 12-20, 2012.
[5] G. Vinod Kumar, J. Srinivasa Rao, J. Amarnath, "Transmission Congestion Management by Using Series Facts Devices and Changing Participation Factors Of Generators," International Journal of Modern Engineering Research (IJMER), Vol. 3, Issue. 4, pp-2111-2118, 2013.
[6] Kanwardeep Singh, Vinod K. Yadav, Arvind Dhingra, "Congestion Management Using Optimal Placement of TCSC in Deregulated Power System," International Journal on Electrical Engineering and Informatics – Volume 4, Number 4, pp 620-632, 2012.
[7] Elango.K, Paranjothi.S.R, "Congestion management in restructured power systems by FACTS devices and load shedding using extended Quadratic interior point method," International journal of applied engineering research, Volume 1, no 4, pp. 767-776, 2011.
[8] Dhanasekar.P, Dr.K.Elango, "Congestion Management in Power System by Optimal Location And Sizing of UPFC", IOSR Journal of Electrical and Electronics Engineering, Volume 6, Issue 1, pp. 49-53, 2013.
[9] Sujatha Balaraman, N.Kamaraj, "Congestion management in Deregulated power system Using real coded genetic Algorithm," International Journal of Engineering Science and Technology, Vol. 2(11), pp 6681-6690. 2010.
[10] N. Sambasivarao, J. Amarnath, V. Purnachandrarao, "Congestion management using facts devices in deregulated power system," International Journal of Research in Engineering and Technology, Volume 02, Issue 11, pp. 90-95, 2013.
[11] Jagabondhu Hazra And Avinash K. Sinha, "Congestion Management Using Multiobjective Particle Swarm Optimization," IEEE Transactions On Power Systems, Vol. 22, No. 4, pp. 1726-1734, 2007.

Author Profile

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