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Alleviating Congestion By Load Curtailment Using PSO

D. FathemaFarzana[1],G.V.Chidambarathanu[2], J.Gowrishankar[3]
[1, 2] *Assistant Professor,*[3]*Associate Professor, Department of Electrical and Electronics*
Easwari Engineering College, Chennai, Tamilnadu,
farzana.reeha@gmail.com

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Abstract

Transmission congestion the executives is one of the basic and significant errands of the System Operator (SO). Power system deregulation and transmission network capacities have led to increased interest in Load Curtailment (LC) sources. This paper shows an explanatory way to deal with distinguish the reason for load reduction and ideal size of LCs based on the Generation Shift Factor (GSF) using Particle Swarm Optimization (PSO) algorithm. A two-stage methodology is used for the optimal size of load curtailment. First GSF is utilized as an objective function to determine the basis for LC. Next, a PSO-based model is used as a target capacity to decide the ideal LC size to limiting framework's genuine power misfortunes. The principle target of Load Curtailment is to calm clog, limit organize control misfortunes and keep up the influence stream inside the framework activity and security imperatives. The proposed structure is shown utilizing an IEEE 30-transport test systems

Keywords: *System Operator (SO) - Load Curtailment (LC) - Generation Shift Factor (GSF) - Particle Swarm Optimization (PSO) - Congestion Management (CM).*

I. INTRODUCTION

The deregulated power showcase requires ideal adjusts between the stock and load progressively. This isn't a simple undertaking on the grounds that both market interest levels could change quickly and startlingly because of age units, constrained blackouts, transmission blackouts and unexpected burden change. The biggest increment of burden has caused clog in transmission arrange, which further lead to unsteadiness in control framework activity. This marvel is primarily because of the development of the deregulated power advertise. The electric power can be transmitted between two areas on a transmission arrange. The few exchange cutoff points, for example, warm breaking points, voltage points of confinement and dependability limits with the most applying at a given time. Blockage in a transmission organize, regardless of whether in vertically coordinated framework or unbundled power showcase can't go on without serious consequences aside from quickly, since this may cause line blackouts with uncontrolled loss of burden. The strategies for the most part embraced to oversee blockage incorporate rescheduling generator yields, providing responsive power bolster or shorten exchanges. A few strategies for clog the executives have been accounted for. In this work, the adequacy of the heap abridgement technique is talked about by detailing the target of accomplishing least genuine power misfortune and mitigating clog on the framework.

A broad and basic investigation on the subject of blockage the executives in control framework has been displayed in the writing. An aggressive market has prompted over-burdening and clog of transmission lines. In addition, transmission organize has ingenerated an increasingly escalated issue of clog. [1]. The significant issue of transmission blockage the executives in a rebuild advertise condition is the thought of voltage security limits [2]. The ideal generator's rescheduling has been acquired for three squares of the offer and offer structure submitted to the ISO in a day-a-head advertise. The base instance of monetary burden dispatch has been gotten for generators guaranteeing as far as possible and age yield information during the clog the executives to get new age planning results [2]. The effectiveness and straightforward arrangement of blockage costs utilizing Modified Bender's disintegration in half and half power showcase is exhibited in[3]. A monetary dispatch with transmission, DR limit and operational imperatives to display the activity of a transmission compelled framework with a high infiltration of wind control is talked about in [4]. To examine the viability of the operational model, straightforward PJM 5-transport framework and an IEEE 118-transport framework is utilized. High infiltration of both Distributed Energy Resources (DER) and Demand Response (DR) in current power frameworks for keeping up framework unwavering quality and adaptability is displayed in [5]. An examination on different effective propelled Real Time Market (RTM) encounters have been condensed and talked about, which gives a specialized diagram of the present RTMs coordinating DER and DR. [6] presents a Demand reaction test system that permits considering request reaction activity and plans in circulation systems . The specialized approval of the arrangement is finished utilizing reasonable system reproduction dependent on PSCAD. In [7] request reaction (DR) through the motivator based and the evaluated based projects. To examine the unwavering quality impacts of DRPs dependent on the DR model the IEEE RTS 24-transport test framework is utilized. Power framework clog is a significant issue of the framework administrator (SO) would look in the post-deregulated zone [8]. Accordingly, examination of procedures for blockage the executives of intensity is of vital intrigue.In spite of the fact that blockage the board utilizing an ideal concentrated power stream gives a productive arrangement, it needs enough straightforwardness in the aggressive power showcase for its members about clog related misfortune and expenses [9]. Transmission line blockage the board in a rebuilt advertise condition utilizing a blend of FACTS gadgets and request reaction (DR) [10]. Results obtained with the proposed methods are compared with that of the sensitivity method and with exhaustive OPF solutions. The overall objective of the FACTS device placement can be minimized the total congestion rent or to maximize the social welfare.An efficient method for transmission line overload alleviation and enhancement of system performance with the integration of Distributed Generators (DGs) is presented in [11]. Maximum Power Stability Index (MPSI) is employed as the objective function to identify the optimal DG location. Then, a Firefly based model with randomized load is evolved to optimize the DG sizing in view of minimizing systems' real power losses. The improvement is measured in terms of voltage profile, congestion relief and available transfer capability using IEEE 30 - bus and IEEE 118 - bus test system

II. PROBLEM FORMULATION

MARKET CLEARING FORMULATION

The market clearing system is planned by following advances. In the initial step, age organizations offering in the market for amplifying their benefit and the ISO clears the market dependent on social welfare augmentation without considering the power arrange

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misfortunes, organize limitations including those of clog as portrayed.

FIRST STEP:MARKET PRICE DETERMINATION

In this progression, it is required to take care of the accompanying compelled enhancement issue:

Maximize:

$$\sum_{i=1}^{N_D}\sum_{k=1}^{N_{Di}}(\lambda_{Dik}-P_{Dik})-\sum_{i=1}^{N_G}C_i(P_{gi}) \text{--- (1)}$$

Subject to:

$P_{Dik}^{min} \leq P_{Dik} \leq P_{Dik}^{max}$ i=1.........N_D,

k=1.........N_{Di}--- (2)

$P_{gi}^{min} \leq P_{gi} \leq P_{gi}^{max}$ i=1.........N_G--- (3)

$$\sum_{i=1}^{N_D}\sum_{k=1}^{N_{Di}}P_{Dik}+P_{fd}=\sum_{i=1}^{N_G}P_{gi} \text{---- (4)}$$

Where,

P_{Dik} = Power block k that demand i is willing to buy at price $\boldsymbol{\lambda}_{Dik}$ up to a maximum of P_{Dik}^{max} .

λ_{Dik} = Price offered by demand i to buy power block k.

P_{fd} = Fixed load based on demand forecasting.

$C_i(P_{gi})$ =Generation cost function.

The goal work (1) speaks to the social welfare, and it has terms. The main term comprises of the whole of acknowledged requests times their relating offering costs, and the subsequent term is the aggregate of the individual generator cost capacities. The square of imperatives in (2) indicates the extents of the interest offers. The square of limitations in (3) restricts the measures of the creation offers. The correspondence requirement in (4) guarantees that the creation ought to be equivalent to the complete interest.

The arrangement of the compelled improvement issue portrayed in (1)- (4) indicates the power created by each generator and the power provided to clients together with the market cost. The subtleties of the two stages for advertise clearing with clog the executives are condensed in the flowchart in Fig.1.

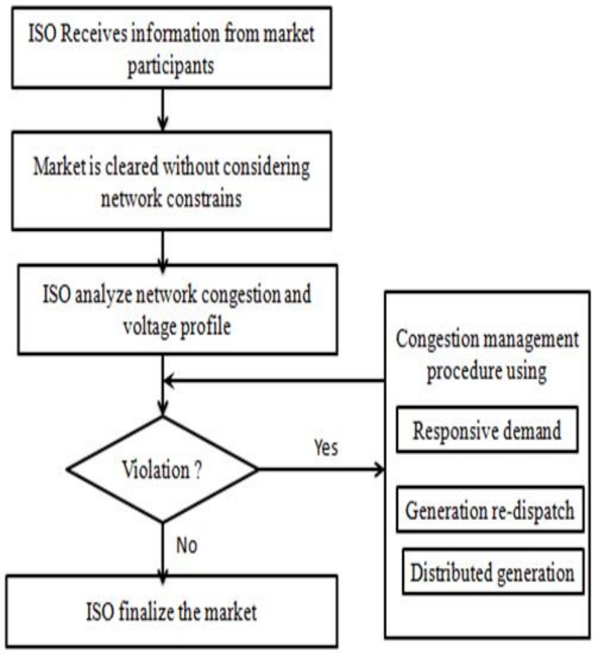

Fig 1: Market Clearing Procedure

IDENTIFICATION OF BUS FOR LOAD CURTAILMENT:

The result of market clearing, congestion occurs in line. The generator sensitivity values are computed for all 24 load buses. Load buses are selected based on the sensitivity values. Here, the load buses with the most negative sensitivity values are selected for load curtailment to alleviate the overload.

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GENERATION SHIFT SENSITIVITY FACTOR:

A simple and fast method for contingency analysis is based on network or linear sensitivity factors namely,

- Generation shift factor
- Line outage distribution factor

GENERATION SHIFT FACTOR:

The generation shift factors are designated as and have the following definitions:

$$a_{li} = \frac{\Delta f_l}{\Delta P_i} \text{-------- (1)}$$

Where,

l=Line file.
i=Bus file.
Δf_l= Change in megawatt control stream on line l when an adjustment in age ΔP_i happens at transport I.
ΔP_i= Change in age at transport I.
The a_{li} factor speaks to the affectability of the stream on hold l to an adjustment in age at transport I. On the off chance that the generator was created P_i^o MW and it was lost, at that point ΔP_i is,

$$\Delta P_i = -P_i^o \qquad \text{------------- (2)}$$

Let $\Delta\delta$ be the change in bus phase angles.
ΔP be the change in bus power injections.

OPTIMAL SIZE OF LOAD CURTAILMENT

Considering another goal is genuine power misfortune minimization. The PSO calculation is utilized to streamline reschedule the dynamic intensity of the generators and power utilization of the heap for alleviating blockage in the influenced lines. Ideal size of burden abbreviation and decrease of complete transmission misfortune is resolved with the assistance of PSO.

OBJECTIVE FUNCTION-LOSS MINIMIZATION:

The objective function for Congestion Management (CM) with loss minimization is given by,

$$f = Min\,(P_{loss}) \text{---------- (3)}$$

Subject to,
$$V_i^{min} < V_i < V_i^{max} \quad \text{------------ (4)}$$

III. RESULT AND DISCUSSION

IEEE TEST SYSTEM:

The IEEE 30-transport framework has been utilized to give the viability of the proposed calculation. The IEEE 30-transport framework comprises of six generator transports, 24 burden transports, 41 transmission lines and all out burden are 283.4 MW as appeared in the Fig.[12] The reproduction is done in MATLAB 10.

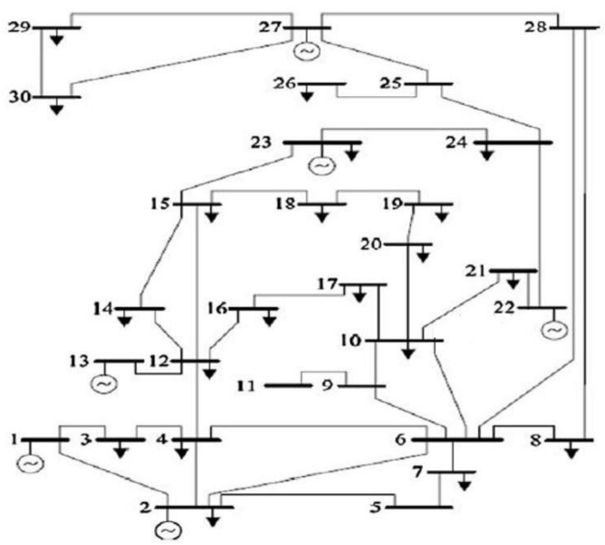

Fig.2 IEEE Test system

MARKET CLEARING DETERMINATION:

The clog the executives because of market clearing in IEEE 30 transport framework is investigated. Market Clearing Price is one of the prime elements of pool administrator. In huge numbers of the current markets, showcase clearing depends on ventured offers got from generators

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and buyers. The market clearing is resolved from the sell offer and purchase offer submitted from each GENCO and shopper as given in Table 1 and Table 2.

TABLE.1. GENERATOR OFFERS

GENERATOR	BLOCK 1		BLOCK 2		BLOCK 3	
	MW	$/MWh	MW	$/MWh	MW	$/MWh
1	12	$20	24	$50	24	$60
2	12	$20	24	$40	24	$70
3	12	$20	24	$42	24	$80
4	12	$20	24	$44	24	$90
5	12	$20	24	$46	24	$75
6	12	$20	24	$48	24	$60

TABLE.2 LOAD BIDS

LOAD	BLOCK 1		BLOCK 2		BLOCK 3	
	MW	$/MWh	MW	$/MWh	MW	$/MWh
1	10	$100	10	$70	10	$60
2	10	$100	10	$50	10	$20
3	10	$100	10	$60	10	$50

After submission of bids the market is cleared and the generator sale and load purchase is shown in Table.3 and Table.4.

TABLE .3 GENERATOR SALE

GENERATOR	QUANTITY SOLD (MW)	SELLING PRICE $/MWh
1	35.3	$50.00
2	36.0	$50.24
3	36.0	$50.34
4	36.0	$51.02
5	36.0	$52.17
6	36.0	$52.98

TABLE.4 LOAD PURCHASE

LOAD	QUANTITY BOUGHT (MW)	LOAD PURCHASES $/MWh
1	30.0	$51.82
2	10.0	$54.03
3	20.0	$55.62

Generator sales and Load purchases graphical representation is given below in Fig .2.

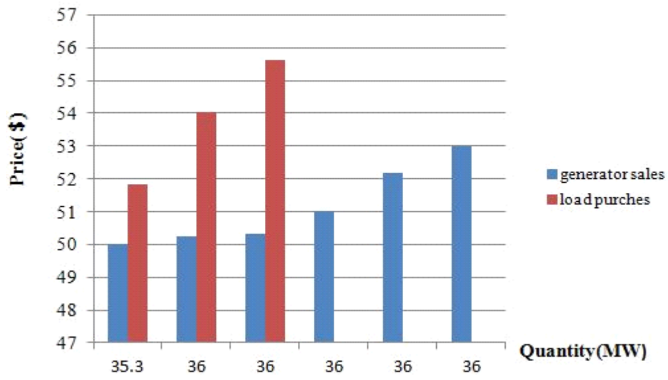

Fig.3Graphical representation of generator and load

The age and request plan landed at because of market clearing causes clog on certain transmission lines. The subtleties of which are appeared in TABLE 5. Clog happens in branch 22 associated between transports 15-18. Here the power stream limit is 16 MW. Because of market clearing the power stream in the line associated between transports 15 and 18 is 17.86 MW, which surpasses the cutoff by 12%.

TABLE.5 POWER FLOW FOR DIFFERENT CONDITIONS

BRANCH CONGESTED	FROM BUS	TO BUS	MAX POWER LIMIT P(MW)	POWER FLOW DURING CONGESTION P(MW)	PERCENTAGE VIOLATION OF LIMIT (%)
22	15	18	16	17.86	12%

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This aftereffect of the transmission network flaws with the result of increment in genuine power misfortunes. The evaluation and minimization of genuine power misfortunes is significant in light of the fact that it can prompt a progressively monetary activity of an influence framework. Consequently, if all the more genuine power misfortunes can be limited, the influence can be used all the more proficiently. The Generator Sensitivities are processed for the blocked lines.

IDENTIFICATION OF BUS FOR LOAD CURTAILMENT:

The resultof market clearing, congestion occurs in line. he generator sensitivity values are computed for all 24 load buses. Load buses are selected based on the sensitivity values. The ranking of load buses with generation sensitivity factors arranged in ascending order.

The fact that all load buses show almost equal influence on the congested lines necessitates that the most negative value of GSF obtained for the test system considered above is -2.5437, -1.7727, -1.4182and 0.5909. The busescorresponding to which the maximum negative value of GSF obtained is 14, 10, 20 and 19. So, these buses are selected for load curtailment using PSO.

OPTIMAL SIZE OF LOAD CURTAILMENT

The optimal size of the LC is varied randomly between 0 to 15% using PSO. As the size of the LC decreases, active power loss of the system decreases. Only at the optimal size of the LC, power loss decreases and loading congestion created gets relieved. Hence it is necessary to find the optimal sizing of LC. Since buses 14, 10, 20 and 19 is considered to be the optimal size of load curtailment. In order to relieve congestion by load curtailment. PSO algorithm is used to find the optimal size of load curtailment. PSO parameters considered is listed below,

TABLE 7. PSO PARAMETERS

PARAMETERS	RANGES
Population size	50
No of parameter	5
Maximum Iterations	100
Acceleration Constants	c1=2;c2=2

In a bigger framework, chose gathering of burdens having the biggest GSF qualities might be utilized to spare the computational exertion. The heaps taking part in blockage the executives and their dynamic power alterations utilizing PSO in a given table. The ideal measuring is appeared in Table 8.

TABLE 8. OPTIMAL SIZE OF LOAD CURTAILMENT USING PSO

S.No	No of Buses	Active Power Demand (MW)	Load curtailed using PSO	Percentage of curtailment (%)	Load reduction P(MW)
1	14	7.2069	0.0748	7.48 %	6.6678
2	20	6.7419	0.0488	4.88 %	6.4129
3	10	2.5572	0.0061	0.61 %	2.5416
4	19	4.0684	0.0219	2.19 %	10.8010

Table 8. Shows the optimal results for the size of the LC. The optimal size of the LC to be varied on the buses is based on the objective of real power loss minimization. The sizes of the LCs are 7.2069 MW, 6.7419 MW, 2.5572 MW and 4.0684 MW in the buses 14, 20, 10 and 19 respectively. Here the LC size is varied randomly between 0 to 15 % using PSO. The convergence characteristics are given in Fig4.

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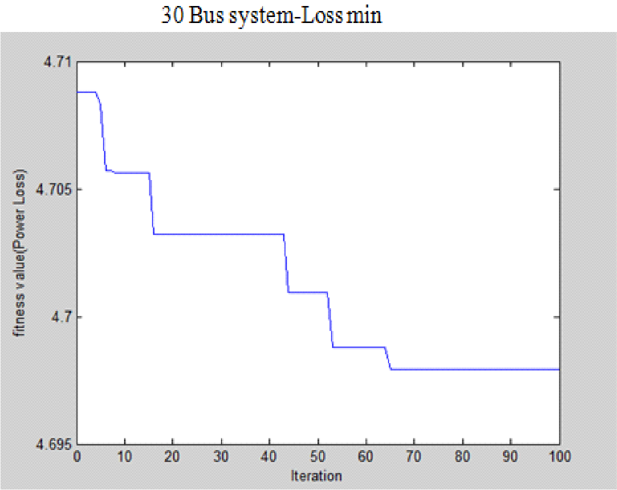

Fig 4: PSO convergence characteristics-loss minimization

Table 9 depicts the system power loss before and afterload curtailment

TABLE 9. LOSSMINIMIZATION USING PSO

NO OF BUSES	BEFORE LOAD CURTAILMENT		AFTER LOAD CURTAILMENT	
	LOAD (MW)	SYSTEM LOSS (MW)	LOAD (MW)	SYSTEM LOSS (MW)
14	7.2069	5.127	6.6678	4.718
20	6.7419		6.4129	
10	2.5572		2.5416	
19	4.0684		10.801	

The real power loss after LC is 4.718 MW, which is reduced by 10.22% from the base case. With this amount of rescheduling of generation, congestion is completely relieved from the congested branch as shown in Table 10.

TABLE 10 .COMPARISON OF RESULT

Congested Branch	From Bus	To Bus	Power flow limit (MW)	Before Load Curtailment		After Load Curtailment	
				Power Flow (MW)	Percentage of power flow (%)	Power Flow (MW)	Percentage of power flow (%)
22	15	18	16	17.8	112 %	15.76	93.75 %

The positive aspect with this proposed objective is that, congestion is completely removed with load curtailment. Before load curtailment the power flow is 17.86 MW and the system loss is 5.127 MW. After the load curtailment, it has decreased to 15.76 MW and the system loss also reduced 4.718 MW, which is reduced by 10.2% from the base case and congestion is relieved. The PSO algorithm produces minimized power loss of 4.718 MW. Hence, from the above table PSO produces better results of load curtailment.

CONCLUSION

Accomplishing a financially straightforward and actually achievable arrangement during transmission blockage represents an extraordinary test to the framework administrator in the focused power advertise. The blockage the executives approach dependent on PSO is effective, limiting the clog the board misfortune. Redispatched loads are chosen dependent on GSF. This work centers around exhibiting the job of interest side cooperation in CM. Request Side Bidding (DSB) is considered during both market clearing and CM stages. The issue of clog is demonstrated as an advancement issue and unraveled by molecule swarm improvement system. The ideal size of LCs relating to least genuine power misfortune is found and subsequently the dynamic influence misfortune is limited by 10.2% from the base case. PSO delivers better outcomes as far as

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limiting force misfortune. The technique has been tried on IEEE 30-transport framework effectively. Test results on the IEEE 30-transport framework demonstrate the proficiency of the proposed methodology in overseeing transmission blockage in a deregulated power systems.

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