IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 1, January 2021

DOI 10.17148/IJIREEICE.2021.9104

Optimal Rescheduling of Generation for Congestion Relief in Deregulated Power Systems

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Abstract: Electricity consumption can be one way of measure of development of country. Deregulation initiates the competition in electricity market which leads to generate more power. Also, a recent power grid is extensive and complicates the power network. The generated power is supplied to consumers through transmission and distribution systems. Compared to the synchronized system the burden on transmission network will be more due to more generation and utilization. These transmission networks violate some line limits which leads to the congestion. The generation rescheduling is one of the better ways to relieve congestion. However, all the generators will not create congestion in transmission lines. In this context a mathematical model was developed to identify the generators which are actively participating in congestion by calculating generator distribution factor using Termite colony algorithm. This proposed mathematical model gives the amount of rescheduling of the selected generators. This method is implemented for slandered IEEE 6 bus system and IEEE 30 bus system to verify the results in theoretical as well as practical using Mi Power software.

Keywords: Deregulation; Congestion; Rescheduling of generators; Termite Algorithm; Generation Sensitivity Factor.

I. INTRODUCTION

Today electricity is daily need to every individual so we need bulk power generation, also the future power system needs to be highly service oriented and caring for consumer values. Competitive or deregulated electricity market gives changes in conventional market structure and it is highly service oriented and caring for consumer values. Because of competition among various generating companies, the generation and usage are more so the transmission network is affected. Here most of the time the power system operates near its rated capacity as the market players have an intention of maximizing profit by utilizing as much as of the existing transmission resources. This led to increase in technical problems in power system such as hamper of voltage security, violation of line flow limits (or) overload of line, increment of line loss, more consumption of reactive power, risk of power system stability, all the above problems can result to a common problem named congestion. Congestion is relieved by using techniques likes using FACTS devices, phase shifting transformers, and rescheduling of active outputs of the generators. Among all here we are using rescheduling of generators because there is no need of using additional Equipment; it is a cost-free method. All generators are need not to schedule, selection of generators is by using contribution factors. Bialek's upstream looking algorithm for finding contribution factors. And the selected generators are scheduled by using proposed mathematical model involving contribution factors and real power flow in the line. This method is done in standard IEEE 6 bus system, IEEE30 bus system.

II. POWER FLOW TRACING METHOD

The algorithm for tracing the flow of electricity will be now derived in two versions.

- The downstream-looking algorithm which looks at the nodal balance of outflows.
- The upstream-looking algorithm will look at the nodal balance of inflows.

The upstream-looking algorithm applied to the gross flows determines how the power output from each of the generators would be distributed between the loads. The downstream – looking algorithm applied to the net flows determines how the demand of each of the loads would be distributed between individual generators if the transmission losses were removed from line flow [1].

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III. TERMITE COLONY OPTIMIZATION

Termite Colony Optimization (TCO) is a novel optimization method based on intelligent behaviour of termites.TCO provides a colony of termites with a stochastic decision-making process. The decision-making process is used by the termites to select their movement patterns. A termite selects a movement pattern based on the local information which is obtained by sending the nearby regions. A termite move randomly, but its movement may influence by observed pheromone in nearby region. A termite tends to move toward a region which contains more pheromones. In this paper we propose a solution method for the congestion problem in deregulated power system using TCO algorithm. We focus on minimizing the number of devices used, while maximizing the coverage of the network. Termite is a simple and tiny insect. Like an ant it also distributes its labor among castes i.e. it works in a social organization. Termite has also foraging behaviors and it can maintain indirect communication using pheromone. Pheromone is a chemical agent consists of molecules which is released from glands of the termite body. Using the environment as a medium for indirect communication is called stigmergy.

IV. EXISTING MATHEMATICAL MODEL

Power flow tracing algorithm is used for the selection of participated generators in the rescheduling. The amount of rescheduling for selected generators is known by using proposed mathematical model. The formula requires contribution factor and real power capability of the congested line. It is clearly explained below. In transmission network the line connected between busses i-j is getting congested and to relieve congestion by rescheduling the generator is done by using below formula,

$$P^{S}GK = \Sigma_{k-1} n \frac{pi-jmax}{DiG-j,k}$$

$P^{S}GK$ -Scheduled real power adjustment at Kth Bus generator
$pi-j^{max}$-Maximum permissible active power flow in the line i-j.
$Di^{G}-j,k$-Generator contribution factor in the line i-j due to Kth Generator.

The above formula given only to change an active power output of generators and to relieve congestion in the particular line i-j. But by this we do not known about whole system any other line in the system may get congested by doing rescheduling using above formula. So considering all lines during congestion management, here every time only two generators participated in the rescheduling. Taking a next weakest line that is when we knowing the capability of this weakest line. By this we achieve congestion free system after scheduling of generators.
Here two generators are participated in congestion management one generator is going to drop off the generation and generator 2 is obviously add to its generation capacity. For example, generator1 is decreasing and G2 is increasing its generating capacity so the power supplied for next weakest line is definitely by G2. The next weakest line determined by contribution factors. By observation, specifically highest contribution factor of G2 is taken as next weakest line. Find the capacity of this line we know the accurate scheduling for all lines in the congested system. Find ΔP^{max} and P^{max} is the maximum power transfer capability of the line it is determined by formula
Pmax= S* PF

ΔP^{max} is the maximum power transfer capability of the line
With the scheduled generator values
ΔP^{max}=G1* distribution factor for the line + G2 * distribution factor of the corresponding line

Case1: when $P^{max} > \Delta P^{max}$
Directly schedule the generator by using above formula (equation 1) it gives optimal solution.
Case2: when $P^{max} < \Delta P^{max}$

In this case the real power capability of the line is exceeds by a new rescheduled output for generators. By this condition congestion is not possible we go for another generator for congestion management.
In case of contingency that is one line is taken as out of service. Then the equation1 is changed like below

$$P^{S}GK = \Sigma_{k=1} n \frac{pi-jmax}{Di\ G-j,k + Dm\ G-n,k}$$

$Dm-n,kG$-generator contribution factor in the line m-n due to Kth generator.
Generator outage: one generator is out of service then the formula is

$$P^{S}GK = \Sigma_{k=1} n \frac{pi-jmax}{Di\ G-j,k - Dm\ G-n,k}$$

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V. PROPOSED METHOD OF RESCHUDLING OF GERERATION INTELLIGENT BEHAVIORS OF TERMITES

A colony of termites is a decentralized system which capable to perform complex tasks using relatively simple rules of individual termites' behavior. Such system contains simple individuals interacting locally with one another and with their environment. Despite a lack of centralized control or any organizational structure, local interactions among simple individuals cause a global pattern to emerge.

The ability of social insects to self-organize relies on four principles: positive feedback, negative feedback, randomness, and multiple interactions. A fifth principle, stigmergy, arises as a product of the previous four [11].Such self-organization is known generally as swarm intelligence. A simple example of the hill building behavior of termites provide a strong analogy to the mechanisms of Termite and optimizing continuous problems in general. This example illustrates the four principles of self-organization. A similar analogy is often made with the food foraging behavior of ants.

A colony of termites has the ability to perform complex task by applying simple rules between its individuals. For example, consider a flat surface upon which termites and pebbles are distributed. The termites would like to build a hill from the pebbles. The termites try to collect all of the pebbles into one place. Termites act independently of all other termites, and move only on the basis of an observed local pheromone gradient. Pheromone is a chemical excreted by the insect which evaporates and disperses over time.

A termite moves randomly, but is biased towards the locally observed pheromone gradient. If no pheromone exists, a termite moves uniformly randomly in any direction. Each termite may carry only one pebble at a time. If a termite is not carrying a pebble and it encounters one, the termite will pick it up. If a termite is carrying a pebble and it encounters one, the termite will put the pebble down.

The pebble will be infused with a certain amount of pheromone. With these rules, a group of termites can collect dispersed pebbles into one place. Similar to other population-based algorithms, the swarm intelligence principals such as positive feedback, negative feedback, randomness, multiple interaction, and stigmergy play important roles in social behaviours of termites.

VI. TCO ALGORITHM

In this section we present the proposed TCO algorithm. The pseudo code of the TCO algorithm is represented in Figure 1. TCO employs stochastic process to find optimal solution. It employs a population of termites which move in a D-dimensional search space S ⊂ RD to find the optimal solution. Assume that we have a population of N termites .Each termite i in the population is associated with a position vector ( ) xi = xi1, xi2…... xiD, which represents a feasible solution for an optimal problem in the Dimensional search space S. In TCO, each position vector represents a hill with an associated quality which is represented as ( ) fit xi. The fitness value models 'number of pheromones which are deposited on the hill. The TCO employs the following scenario to optimize a numerical function

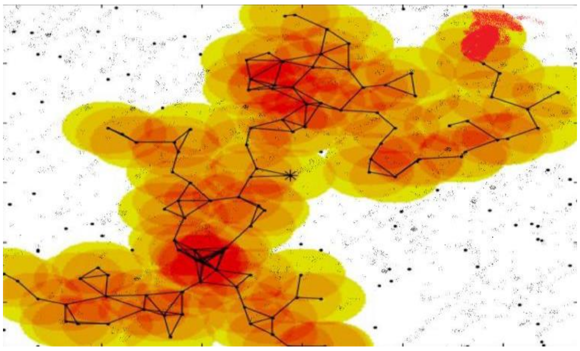

Figure 1: A possible solution to the rescheduling of generation Network Problem where HECN is High Energy Communication Node

Initially, number of the termites, and maximum number of iterations, Itermax, is determined. After that, at the start time of the algorithm all of the termites are position randomly in the search space:

Xi (0) = Init (i, S) 1≤ i ≤ N (1)

Wherein it(i, S) is the initialization function which associates a random position to the termite i in the search space S. After initialization, the termites employ the following process to adjust their positions throughout iterations until the termination condition is met. At each cycle of the algorithm, the fitness value of each termite is evaluated. The fitness value is used for computation of pheromone content at each location of termites. The pheromone content at the j-th location I computed based on the following equation:

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$$\tau i\ (t) = (1-\rho)\ \tau i\ (t-1)+1\ (\ fit(xi\ )+1)\ (2)$$

Where, ρ is the evaporation rate that is taken in range of
[0...1], ( ) 1 − t i
τ and ( ) t i
τ respectively are the pheromone level at the current and previous locations of i-th termite .After computing the pheromone levels at the locations of termites, each termite adjusts its trajectory based on local information and moves to new location. The termite movement is a function of pheromone level at the visited location and the distance between a termite location and the visited locations. Based on these, two different movement patterns introduced for termites. A local region around each termite is considered, and the number of visited position in the neighborhood of the termite is computed. If there is no visited position in the neighborhood of a termite, it moves randomly in its own nearby regions. Termites with one or more visited positions in their neighborhood may select a more profitable position and move toward that position. A part of termites employ a random movement pattern in order to find more profitable regions. The random walk is performed by the termite in a region with radius τ . The search region is centered at current position of the termite. So the next position of a termite is updated using the following equation:

$$Xi\ (t) = xi\ (t-1) + Rw\ (,\ xi\ (t-1))$$

Where xi (t −1)
Represents the previous position of the termite which is replaced by the new the new position of that termite (i.e. xi (t −1)), and Rw is a random walk function that depends on the current position of the termite and the radius search τ. The initial value of radius τ is defined as a percentage of Xmax − Xmin, where X max and Xmin respectively represent the maximum and minimum values of the search space along a dimension. The value of τ is linearly decreased from τ max to τ min throughout iterations. The termites adjust their walking based on the τ.The large value of τ at the first iterations enables termites walking with large step size to explore wide regions in the search space. While the small values of τ in the last iterations encourage the scout termites to walk more precisely within small regions

Proposed TCO algorithm is given bellow:

01. Initialization
02. Determine N, Tr and itermax
03. for (all termite t)
04. Xi/O) = lnit (t)
05. End For
06. While (iter<itermax)
07. Compute fitness, fitness(X)
08. for (all available location site)
09. Tij (t) = (1 - e) x Tij (t) + 1/ (fitness(X) + 1)
10. End For
11. for (all termite t)
12. Find the neighbor positions for termite t
13. If termite t has neighbors then
14. Select neighbor ALS with higher probability Pij.
15. Else
16. Select a position randomly.
17. End if
18. End For
19. Adjust the radius Tr
20. End While

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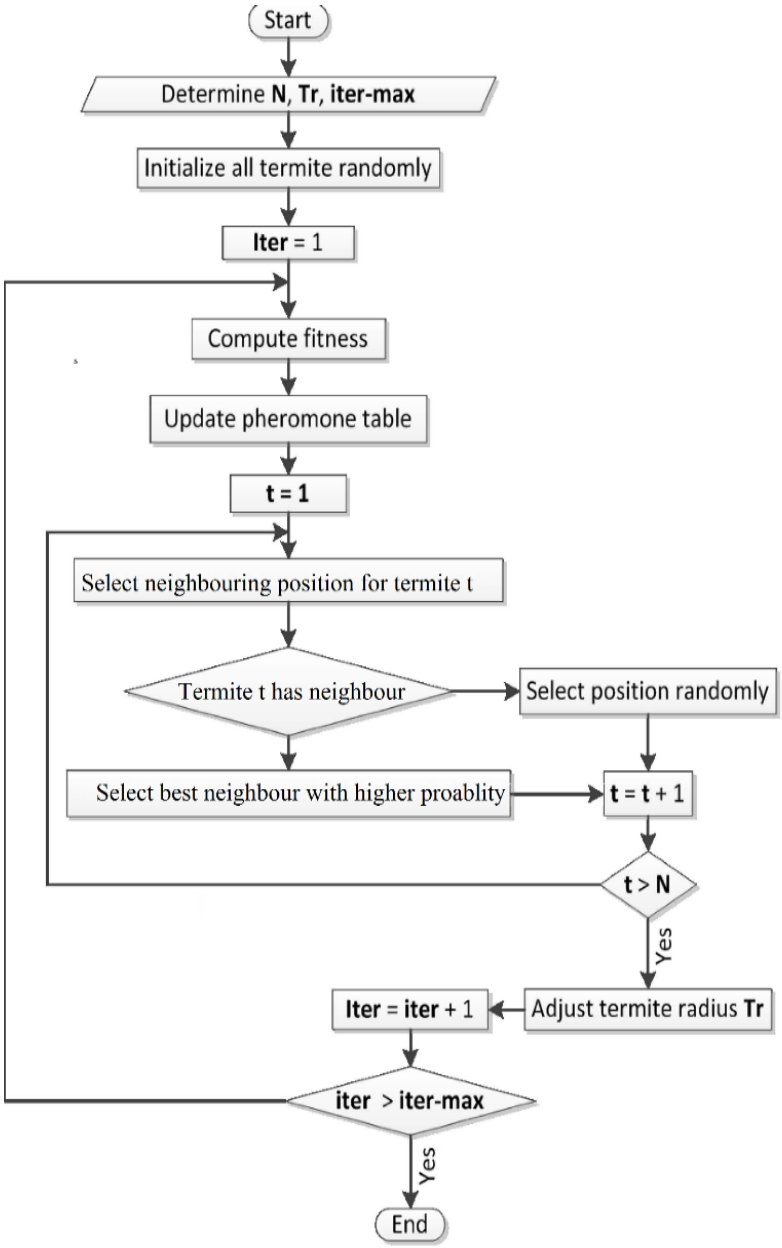

Fig.2 Flow chart of proposed TCO algorithm

VII. CASESTUDYANDRESULTS

To relieve the congestion in a line firstly identified the participated generators to the congestion by calculating the contribution factors of the generators using power flow tracking algorithm. Secondly, each generator contribution for power flow in each line is calculated. Thirdly, in order to maintain the system stability and security, generation of the participated generators is rescheduled using proposed mathematical modeling. Verified all the constraints such as line power flows and voltages are within specified limits.

a. CASE STUDY 1: IEEE 6 BUS SYSTEM

IEEE 6 bus system is considered as test case 1 which has 2 generators, 5 transmission lines and 4 loads as shown in figure 3. To create congestion in a line (2-3) the MVA rating of the line is decreased from 100MVA to 80 MVA. That the loading of the line (2-3) is increased from 85% to 106.8%. And the line is considered as congested line. After taking the power flow of 6 bus system the line flows and percentage of line loadings are obtained and tabulated in table 1.
Table 1: Line Flows and % loading for IEEE 6 bus system before rescheduling

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S.No	From Bus	To Bus	Forward		% Loading
			MW	MVAr	
1	1	5	293.885	-82.719	198.5
2	2	6	54.953	2.343	35.8
3	1	2	44.000	-16.389	50.7
4	1	3	125.236	-48.613	145.1
5	1	4	116.907	-37.547	132.6
6	2	3	37.050	-19.933	45.5
7	2	4	59.714	-21.008	68.5

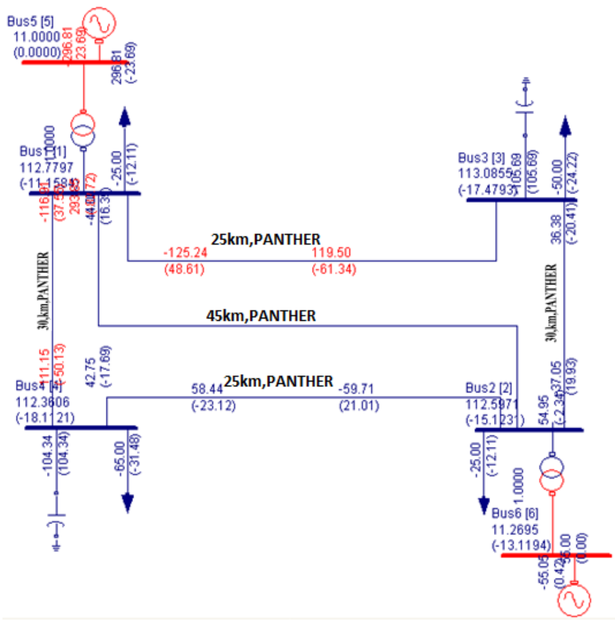

Fig 3: AC power flow in IEEE 6 bus system

Table 2: Contribution Factors & Power Flows for IEEE 6 bus system

Lines	Actual power flows (MW)	Contribut ion of generato r G1 (MW)	Contribu tion of generato r or G2 (MW)	Contribu tion Factor (D)	
				G1	G2
1-2	293.48	293.48	0	0.71	0
1-3	54.953	54.953	0	0.42	0
2-3	44.000	44.000	7.648	0.16	0.1711
2-4	125.23 6	125.23 26	8.644	0.17	0.2511
2-5	116.90 7	116.90 7	16.928	0.214	0.4712
3-4	37.050	37.050	2.228	0.1241	0.0617
4-5	59.712	59.712	1.472	0.032	0.0348

By using POWERFLOW TRACKING method we finding generators contribution factors for each line and by this we knowing that how much the generators giving real power to each line and these values are tabulated above. Based on contribution factors, the generation rescheduling is made according to the proposed termite algorithm.

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A.1 Normal Case: Line (2-3) is Overloading

Consider a generators maximum generating capacity as,
G_2^{max}=140MW and G_3^{max}= 55MW

Table 3: Table of maximum generating capacities of generators

Generator Number	Maximum generating capacity generators (MW)	Generating cost (500 $/MWhr)
G2	160	500
G3	55	380

From the table 3, the line connected between bus1 and bus 3 is taken as red because, by the table 2 the percentage of loading in that corresponding line is 106.8 so the line is considered as congested (overloaded). Here the overloading relieved by using rescheduling of generators. Amount of generators rescheduling is known by using formula given below

$$P^S GK = \Sigma_{k=1}n \frac{pi-jmax}{Di\ G-j,k + Dm\ G-n,k}$$

P^SGK-scheduled real power adjustment at bus Kth generator

$pi-j^{max}$-Maximum permissible active power flow in line i-j

$DiG-j,k$-Generator contribution factor in the line i-j due to Kth generator.

The contribution factor is already given in table 5 and to find $Pi\text{-}j^{max}$

Consider the line 2-3 is overloaded and MVA rating of the line is 80.
Sbase= 80 MVA

By equation

Actual MVA = 80*1.045= 83.6 MVA
The phase angle at bus 1 is 0 so, Power factor = Cos (0) =1
Real power capability of the line is measured by using formula
P= 83.6*1 = 83.6 MW

$$P_{G1}{}^{s} = \frac{83.6}{0.6801}$$

The maximum power capability of line 1-2 is 83.6 MW and by using equation

$$P_{G1}{}^{s} = \frac{83.6}{0.6801} = 122.92\ \text{MW}$$

So G1=122.92MW and generator 2 is scheduled by using equation (19) we get
$G2s$= 129.74 - 122.92 + 40 = 46.82 MW

Scheduled real power adjustment at generator 1 and Generator 2 is obtained but here we do not know about other lines. So here we want to schedule generators by considering all lines flow. This is the reason i am taking a next weakest line i.e., When we knowing the capability of this weakest line. By this we achieve congestion free system after scheduling of generators.

Here, the generation output at generator 1 is going to decrease and at generator2 output is going to increases so the next weakest line is affected by generator 2 only by above tabular column the line connected between busses 2-3 is considered as next weakest bus for generator 2, because contribution factor for the line 1-3 is more compared to all the remaining lines.

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Table 4: Representation of next weakest bus for IEEE 6 bus system

Lines	Actual power flows (MW)	Contribution of generator G1 (MW)	Contribution of generator G2 (MW)	Contribution Factor(D)	
				G1	G2
1-2	293.44	293.44	0	0.70	0
1-3	54.921	54.921	0	0.419	0
2-3	43.991	43.991	7.648	0.158	0.17
2-4	125.23	125.23	8.644	0.168	0.25
2-5	116.8	116.8	16.928	0.212	0.471
3-4	36.918	36.918	2.228	0.123	0.060
4-5	59.6	59.6	1.472	0.031	0.034

The next weakest line is 2-3, find the real Power capability of that line.
MVA of the line =60
Actual MVA = 60* 1.0345 = 61.902MVA
P.F = Cos (-0.288) = 0.99
P = 61.902*0.99 = 61.82 MW$P2{-}3max$= 61.82 MW
$P2{-}3max$is the maximum active power transmittable capacity of a line connecting between busses 2-3. And the change in$P2{-}3max$after changing the scheduled generator values substitute G1 = 122.92 and G2 = 46.82
$P2{-}5max$= (46.82×0.4232) + (122.92×0.2878) = 55.19 MW
Here $P2{-}3max > \Delta\ P2{-}3max$so the scheduling processes
Satisfies to all lines (no other line is overload) directly schedule the generator by using equation it gives optimal solution.

$$P_{G1}{}^{s}= \frac{83.6}{0.6801}= 122.92\ \text{MW}$$

The actual power flow in the congested line is decreased to,
$P1^{\,s}-2 = P_{G1}{}^{s} \times D1^{\,G}-2{,}2$
=122.92 ×0.5464 = 83.5 MW
The scheduled generator values i.e., G1=122.92MWand G2= 46.82MW are giving to IEEE 6 bus system and execute it then we get the congestion free system. The corresponding results are shown as follows.

Table 5: Line Flows and % loading for IEEE 6 bus system after rescheduling

S. No	From Bus	To Bus	Forward		% Loading
			MW	MVAr	
1	1	2	283.85	-81.719	195.2
2	1	3	51.953	2.43	36.4
3	2	3	42.000	-16.39	50.12
4	2	4	123.236	-48.63	142.1
5	2	5	114.907	-37.54	132.5
6	3	4	34.050	-19.3	44.5
7	4	5	57.714	-20.998	67.1

From the above table it is clearly observed that for line flows and percentage of loadings after relieving congestion by using proposed and developed mathematical model. The below figure shows that the congestion free system after relieving congestion.

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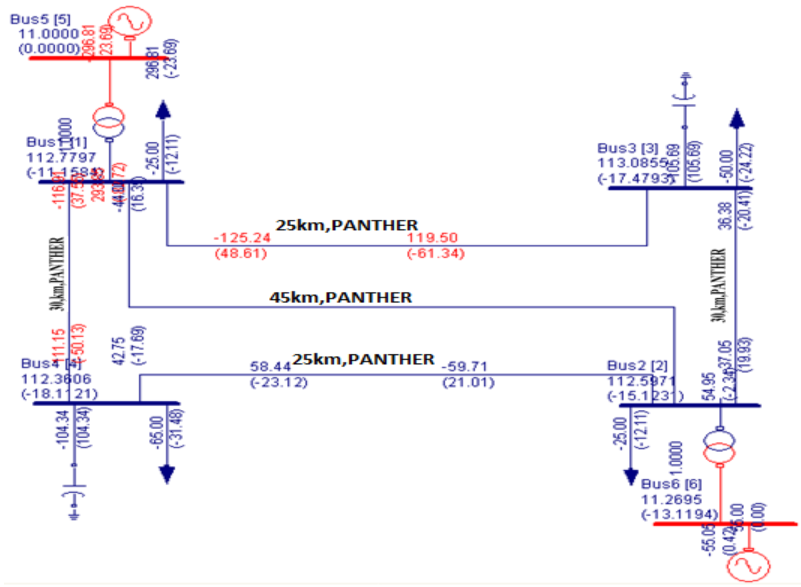

Fig 4: AC power flow in IEEE 6 bus system after congestion relief

The line (1-3) in the above table represents that the line is congestion free the overloading in the line is eliminated by after rescheduling the generators with scheduled generator values getting from above formulas that is change the generator values by theoretical values. The table is taken by note pad results from MIPOWER software. The percentage of loading in the line 2-3 is 98.8, so the congestion in line (2-3) is relieved.

A.2. Contingency Analysis (line 1-3 outage)

Consider an IEEE 6 bus system and take one line (2-3) is out of service.

Table 6: Line Flows and % loading for IEEE 6 bus system before rescheduling with line 2-3 outage

S. No	From Bus	To Bus	Forward		% Loading
			MW	MVAr	
1	1	2	288.85	-81.719	196.2
2	1	3	LI NE IS OPEN		
3	2	3	42.000	-16.39	50.12
4	2	4	123.236	-48.63	142.1
5	2	5	114.907	-37.54	132.5
6	3	4	34.050	-19.3	44.5
7	4	5	57.714	-20.998	67.1

The actual power flow in the line connected between busses 1 and 2 is 132.04MW and line is loaded by 126.5%. So the line is considered as congested line. The congestion in the system is relieved by using formula shown in equation it is shown in below.

The contribution factors are already given in table 5 and to
Find $Pi{-}jmax$

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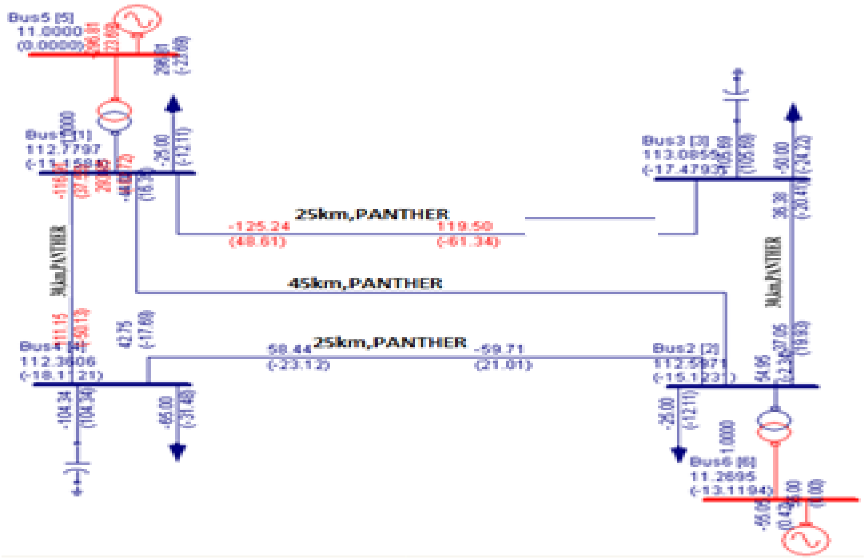

Fig 3: AC power flow in IEEE 6 bus system

The contribution factors are already given in table 5 and to FindP_{i-jmax}

Consider the line 2-3 is overloaded and MVA rating of the line is 100.

$Sbase$= 100 MVA

Actual MVA = 100*1.045

= 104.5 MVA

The phase angle at bus 1 is 0 so,

Power factor = Cos (0) =1

Real power capability of the line is measured by using formula in equation (17), we get

P=104.5×1= 104.5 MW

The maximum power capability of line 1-2 is 104.5 MW. By using equation (20)

$$P^{S}GK = \Sigma_{k=1}^{n} \frac{p1-3max}{D1\ G-3,1+D1\ G-3,1}$$

$$P^{s}G1 = \frac{104.5}{0.6801+0.313} = 105.22 \text{ MW}$$

So G1=105.22 MW and generator 2 is scheduled by equation (19),

$G2^{S}=G1^{old}-G1^{new}+G2^{old}$

= 132.04 – 105.22+40

= 66.82 MW

Scheduled real power adjustment at generator 1 and generator 2 is obtained but here we do not know about other lines. So here we want to schedule generators by considering all lines flows. Because of this reason a next weakest line is considered. i.e., When we knowing the capability of this weakest line. By this we achieve congestion free system after scheduling of generators.

Here, the generation output at generator 1 is going to decrease and at generator 2 output is going to increases so the next weakest line is affected by generator 2 only by above tabular column the line connected between busses 2-3 is considered as weakest bus for generator 2 because contribution factor for the line 2-3 is more compared to all the remaining lines.

The next weakest line is 2-3, find the Real Power capability of that line.

MVA of the line =100

By equation (18),

Actual MVA = 100* 1.0345 = 103.45 MVA

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

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p.f = cos (-0.288) = 0.99
P = 103.45*0.99 = 102.41 MW
$P3{-}5^{max}$= 102.41 MW
$P3{-}5^{max}$ is the maximum active power transmittable capacity of
a line connecting between busses 2-3. And the change in $P3{-}5max$after changing the scheduled generator values substitute G1 = 122.92MW and G2 = 46.82MW.
$P3{-}5^{max}$= (66.82×0.4232) + (105.22 × 0.2878) = 58.56 MW
Here $P3{-}5^{max} > \Delta P3{-}5^{max}$
So the scheduling process is satisfying to all lines (no other line is overload)directly schedule the generator by using equation (20) it gives optimal solution.

$$PG1^{s} = \frac{103.936}{0.6801+0.313} = 105.22 \text{ MW}$$

The actual power f p low in the congested line is decreased to,
$PG1s = PG1s \times D1{-}2{,}2G$= 105.22 (0.6801+0.313)
= 104.4MW
The scheduled generator values i.e.
G1=105.22MW andG2= 66.82MW
Are giving to IEEE 6 bus system and execute it then we get the congestion free system. It is clearly shown by the below figure and note pad results. The line connecting between busses 2-3 congestion free shown in bold.

Table 7: Line Flows and % loading for IEEE 6 bus system after rescheduling for line 2-3 outage

S.No	From Bus	To Bus	Forward		% Loading
			MW	MVAr	
1	1	2	288.85	-81.719	196.2
2	1	3	LI NE IS OPEN		
3	2	3	42.000	-16.39	50.12
4	2	4	123.236	-48.63	142.1
5	2	5	114.907	-37.54	132.5
6	3	4	34.050	-19.3	44.5
7	4	5	57.714	-20.998	67.1

The line flows and percentage of loadings for 6 bus system after relieving congestion is shown above. In congestion the percentage of loading in the line 2-3 is 106%after relieving congestion by using developed proposed mathematical model the percentage of loading in the line is decrease to 99.9%. So by this we knew that the congestion is relived here effectively. It is clearly shown by the below figure (it is a plotted graph in MiPower software.
The line is congestion free the overloading in the line is eliminated by after rescheduling the generators with scheduled generator values getting from above formulas that is change the generator values by theoretical values. The table Is taken by note pad results from MiPower. The percentage of loading in the line 2-3 is 99.5%, so the congested line in the system is relieved.

IEEE 30 bus system
IEEE 30 bus system is taken as test case 2 which has6 generators 41 transmission lines and 20 loads are shown in figure. After taking the power flow of 30 bus system the line flows and percentage of line loadings are obtained and tabulated in table.

IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 9, Issue 1, January 2021

DOI 10.17148/IJIREEICE.2021.9104

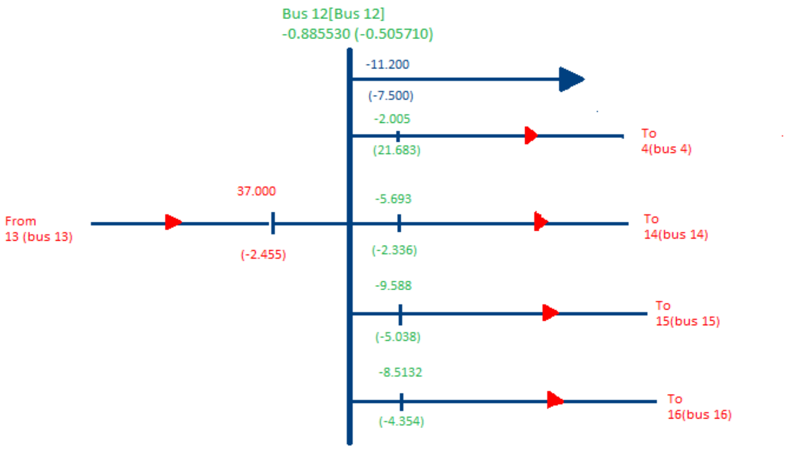

Figure 6: Power flows at bus 12 in a part of IEEE 30 bus System

Table 8: Line Flows and % loading for IEEE 30 bus system before rescheduling

From bus	To bus	Power in line 15-16 (MW)	% Loading
15	16	55	125.5

From the above table it is clearly observed that the power flow in the line connecting between busses (12-13) is37MW and the percentage of loading in the line is 119.6%.That the line is loaded 19.6 percent more than the line rated MVA and the line (12-13) is considered as overloaded line shown in red color.

After finding this matrix ($AU{-1}$) the formulas given inequation 4 and 6 used to find the generator contribution factor, after getting contribution factor calculate power flow at eachbus. And the below tabular form shows each line flows in transmission network and contribution factors for each line. The contribution factors at each line are calculated.
Table 10: Line Flows and % loading for IEEE 30 bus system after rescheduling

From bus	To bus	Power in line (MW)	%loading
15	16	44.56	99.5

The line (1-3) in the above table represents that the line is congestion free the overloading in the line is eliminated by after rescheduling the generators with scheduled generator values getting from above formulas that is change the generator values by theoretical values

VIII. CONCLUSIONS

In this paper, the critical requirement of the consumer are reliability and better performance over restricted market environment is solved by rescheduling the generation of the generators participating in congestion. The Power flow tracing algorithm is used to trace the power flow in each line and contribution factors for each line. Contribution factors are determined for selection of generators. The selected generators are rescheduled by using proposed and developed mathematical model for rescheduling of selected generators. Minimization of congestion in overloaded line is achieved by the following method so that all the line power flows and voltages are within specified limits. This mathematical model is implemented and validated the results for standard IEEE 6 bus system and standard IEEE 30 bus system in both normal as well as contingency cases.

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

IJIREEICE

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

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DOI 10.17148/IJIREEICE.2021.9104

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