IJCTA, 10(03), 2017, pp. 49-61

Multi-Objective Congestion Management in a Deregulated Power System using Hybrid MOPSO Algorithm with FACTS Devices

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Abstract : In a deregulated power systems, congestion management is one of the technical problem and it needs to maintain the system as stable condition. Several objective functions are considered to optimize the congestion management. Here three objective functions are taken an account, which is Real power loss minimization, Voltage stability Index(L-index) minimization and Social Welfare maximization. Two types of Methodologies used in congestion Management are non-cost allowed methods and cost allowed methods. In this research work congestion is released by using cost allowed methods considering FACTS (Flexible AC Transmission Systems) Devices such that SVC(Static VAR Compensator) and TCSC(Thyristor controlled series Compensator) devices. The best location of FACTS device like SVC and TCSC are found by using modal analysis. These Multiobjectives with constraints are solved using intelligent techniques like NSGA-II(Non-dominated Sorting Genetic Algorithm-II), MOPSO(Multi-objective particle swarm optimization) and HMOPSO(Hybrid MOPSO).The results are compared and the performance analysis has been worked out for IEEE30 test bus systems using Matrix laboratory (MATLAB) with necessary alterations in Matpower4.1 coding. The result shows that the proposed approach has a capability to enhance the Voltage stability, minimize that real power loss and maximize the Social Welfare in the power systems network.

Keywords : Congestion Management, PSO, HMOPSO, TCSC, UPFC, Social welfare, L-index, Real power loss.

1. INTRODUCTION

In a regulated power system environment Generation, transmission, Distribution are controlled in a single company, but in a deregulated power system environment has different entities like GENCOs (Power Generation Companies), TRANSCOs (Power Transmission Companies), DISCOs (Power Distribution Companies), ISO (Independent system operator), RESCO (Retailer). The ISO has the responsibility of ensuring the security and reliability of entire power system. The power transaction between the companies, overloaded condition and sudden line outage will create congestion in a transmission lines. In Modern days power system had complicated networks .It has hundreds of generating power stations and substations. The electric power transfer in multi machine systems is constrained by line outage, generator outage, change in energy demands and uncoordinated transactions. Two cases are considered here that is heavy loaded condition and heavy load with worst line outage. In this paper three main objective function of congestion management(CM) taken here, that is Maximization of social welfare, Minimization of losses in real power and Minimization of Voltage stability Index(L-index). These Multi-objective functions optimized and compared using the algorithms NSGA II, MOPSO and HMOPSO. These algorithm results compared without FACTS devices and with SVC and TCSC FACTS devices. The location of the FACTS

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devices found by using Modal analysis [30].Transmission switching is considered here and congestion solved using benders decomposition technique[1]. The objective functions Social welfare maximization, real power and reactive power generation cost and LMP are solved using Price responsive demand shifting (PRDS) bidding mechanism[3].Generation cost, voltage profile improvement and FACTS cost function are considered here these objective functions solved using Coordinated aggregated-based particle swarm optimization algorithm(CAPSO)[4]. Social welfare, LMP cost and real power losses considered here and UPFC device optimally located here [5] MOPSO algorithm used to solve congestion management problem[6]. Multiobjective case considered Congestion cost, Voltage stability and transient stability solved using modified augmented *e*-constraint method[15]. Multiobjective Decentralized CM solved using Modified NSGA-II[20]. Multiobjective fuzzy evolutionary programming (FEP) and NSGA-II used to optimize congestion management problem in IEEE 30 bus system[23]. L- index used for voltage stability enhancement[28].Matpower4.1 used to solve load flow analysis[29]. Hybrid MOPSO used to solve multiobjective problem and comparatively got the best result with other recent algorithms[32].The control variables used in the multiobjective problem is generator real power settings (P_{Gi}) and voltage settings(V_{Gi}), transformer tap settings (T_i), reactive power compensation setting(Q_{ci}). It is desirable to install series controller in the line where active power control is needed, and shunt controller in buses where reactive power control is needed to support the voltage. Applications of this paper is to locate optimally and setting of SVC and TCSC for voltage security enhancement.

2. PROBLEM FORMULATION

2.1. Social welfare maximization

In the power system network supplier and consumer is available. The supplier generates the power and makes a profit. $C_{Gi}(P_{Gi})$ is real power generation cost function and it is the difference between incomes received from power and production cost. $C_{Dj}(P_{Dj})$ is a demand cost function; it is a difference between what customer willing to pay and what he pays actually. The objective function of social welfare is to minimize the gap between generation cost function and demand cost function. If the gap minimized then the social welfare is maximized.

The objective function (F1) is minimization of gap between supply and demand cost function, which is in equation (1)

$$\mathrm{Min}\left(\sum_{i=1}^{NG} C_{Gi}(P_{Gi}) - \sum_{j=1}^{ND} C_{Dj}(P_{Dj})\right) \rightarrow \text{Social benefit} \tag{1}$$

Where,

P_{Gi} → Real power generation in bus *i*.

P_{Dj} → real power demands in bus *j*.

N_G → Total number of generators.

N_D → Total number of load bus.

2.2. Minimization of real power loss

Due to the transaction between generator node and demand node, the real power and reactive power losses are there in the transmission lines. Our aim is to minimize the losses in the power system network. The objective function(F2) is to minimize the real power losses in the network. This is in equation (2)

$$\mathrm{Min}\ F_2 = \mathrm{Min}$$

$$P_{loss} = \sum_{i=1}^{N_L} G_{ij}(V_i^2 + V_j^2 - 2V_iV_j\cos(\delta_i - \delta_j)) \tag{2}$$

where

V_i, V_j → Magnitude of voltage at bus *i* and bus *j*

G_{ij} → Conductance in the line $i - j$

δ_i, δ_j → Angle of voltage in the bus *i* and bus *j*

N_L → Total numbers of transmission lines

2.3. Minimization of voltage stability index

In a power system network voltage needs to maintain as stable due to the abnormal conditions. By using voltage stability index(L-index) method the voltage stability is maintained in a congested power system. The L-index method is suggested by Glavitsch and Kessel[28]. The L-index value ranges from 0 to 1, 0 states that the system is in no-load condition and 1 is for voltage collapse stage. Lindex is the voltage stability indicator of the bus system. If the L-index at the bus is high means, that bus is highly affected due to congestion. The steps used to find out L-index.

N_B → Total numbers of buses in a power system.

N_G → Total numbers of generators in a power system. The voltage and current relationship is,

$$I_{bus} = Y_{bus} * V_{bus} \tag{3}$$

Rewrite the equation(3) to separate the generator(PV) and load(PQ) buses.

$$\begin{bmatrix} I_G \\ I_L \end{bmatrix} = \begin{bmatrix} Y_{GG} & Y_{GL} \\ Y_{LG} & Y_{LL} \end{bmatrix} \begin{bmatrix} V_G \\ V_L \end{bmatrix} \tag{4}$$

Where V_G, V_L and I_G, I_L denotes voltages and currents in PV, PQ buses.

Reorganizing the equation(4)

$$\begin{bmatrix} V_L \\ I_G \end{bmatrix} = \begin{bmatrix} Z_{LL} & F_{LG} \\ K_{GL} & Y_{GG} \end{bmatrix} \begin{bmatrix} I_L \\ V_G \end{bmatrix} \tag{5}$$

$Z_{LL}, F_{LG}, K_{GL}, Y_{GG}$ → Sub matrices created from Ybus.

$$F_{LG} = -[Y_{LL}]^{-1}[Y_{LG}] \tag{6}$$

The equation of L-index at node *j* can be written as:

$$L_j = \left| 1 - \sum_{i=1}^{N_g} F_{ji} \left(\frac{V_i}{V_j} \right) \angle(\theta_{ji} + \delta_i + \delta_j) \right| \tag{7}$$

where V_i, V_j → Magnitude of voltage at bus *i* and bus *j*

θ_{ij} → The phase angle of F_{ji}

δ_i, δ_j → Phase angle of voltage at the bus *i* and bus *j*

N_G → Total numbers of generators.

L_j → Lindex at bus *j*

F_{ji} can be find from the sub matrix F_{LG}.

$$L_{max} = \max(L_j) \tag{8}$$

L_{max} value is found from the maximum Lindex value at the buses. The third objective function (F3) is Minimization of L- index(L_{max}).

$$\text{Min } F_3 = \text{Min } L_{max} \tag{9}$$

If L_{max} value minimum then the system voltage is stable. By using that Voltage stability of the system can be found.

2.4. Modeling and placement of FACTS devices

The optimal location and modeling of SVC and TCSC devices used to improve Congestion in a deregulated power system.

2.4.1. Mathematical model of SVC and TCSC

SVC is a shunt Compensator and is modeled as thyristor controlled reactor shunted by series capacitor bank, it is shown in Figure 1. Inductive compensation and capacitive compensation both are used in SVC. In this work, SVC is modeled as ideal reactive power injection at bus *i*:

$$\Delta Q_i = Q_{svc} \tag{10}$$

The reference voltage is inbetween 0.9pu to 1.05pu and the operating range of SVC is inbetween –200MVAR and 200MVAR

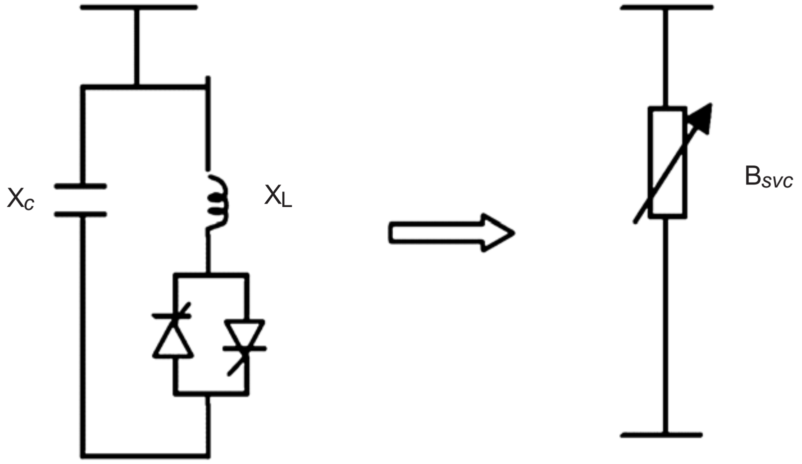

Figure 1: A basic structure and model of Static VAR Compensator(SVC)

TCSC is a Series Compensator and is modeled as series capacitor is shunted by Thyristor controlled reactor and it is shown in Figure 2. It acts as the capacitive compensator or inductive compensator by modifying the reactance of transmission line. In this work, the model of TCSC by changing transmission line reactance as follows:

$$\begin{aligned} X_{ij} &= X_{\text{line}} + X_{\text{TCSC}} \\ X_{\text{TCSC}} &= r_{\text{TCSC}} - X_{\text{line}} \end{aligned} \tag{11}$$

where $X_{\text{line}} \rightarrow$ Transmission line reactance,

$r_{\text{TCSC}} \rightarrow$ Degree of compensation of TCSC.

The level of applied compensation of TCSC varies from 20% inductive and 80% capacitive.

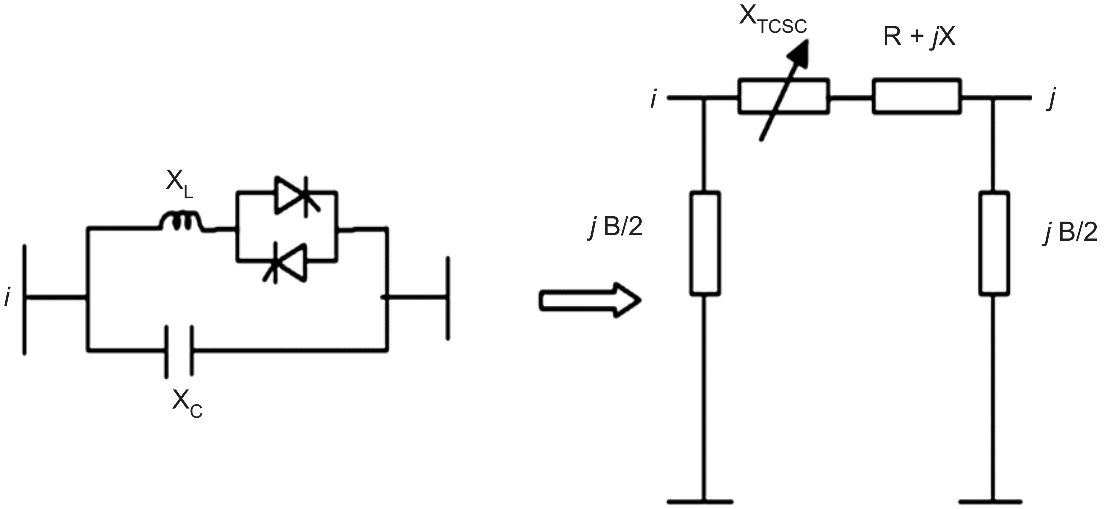

Figure 2: A basic structure and model of Thyristor Controlled Series Compensator (TCSC)

2.4.2. Placement of FACTS devices

Suitable locations of SVC and TCSC are determined using Modal Analysis. This technique provides indications of system conditions with voltage stability problems. In this approach, the location of system buses and branches that have the most effect on the critical modes are identified based on system reduced Jacobian matrix under contingency conditions. The locations of buses and branches are identified using participation factor which are computed using the right and left eigenvectors of the Jacobian corresponding to the zero eigenvalue at the nose point. The size of bus participation in a given mode indicates the effectiveness of remedial action applied at that bus in stabilizing the mode. Branch participation indicates the elements which are critical to the stability of a given mode. A candidate data set is decided, related to the highest participation factors of buses and transmission lines in the system in which the shunt and series FACTS controllers are placed which have the highest bus and branch participation factors

2.5. Problem Constraints

The List of Equality constraints and Inequality constraints are below.

2.5.1. Equality Constraints

Equality constraints of the given objective functions are

$$\begin{aligned} P_{Gi} - P_{Di} &= V_i \sum\nolimits_{j=i}^{NB} V_j [G_{ij} \cos(\delta_i - \delta_j) + B_{ij} \sin(\delta_i - \delta_j)] \\ Q_{Gi} - Q_{Di} &= V_i \sum\nolimits_{j=i}^{NB} V_j [G_{ij} \cos(\delta_i - \delta_j) + B_{ij} \sin(\delta_i - \delta_j)] \end{aligned} \tag{12}$$

$P_{Gi}, Q_G \rightarrow$ Real power & reactive power generations at bus i.
$P_{Dj}, Q_{Di} \rightarrow$ Real power and reactive power demands at bus i.
$G_{ij} \rightarrow$ Conductance in between the line $i - j$
$B_{ij} \rightarrow$ Susceptance in between the line $i - j$
$i \rightarrow 1$ to N_B,
$N_B \rightarrow$ Total numbers of bus.

2.5.2. Inequality Constraints

Inequality constraints of the given objective functions are

$$P_{Gi,\min} \leqq P_{Gi} \leqq P_{Gi,\max} \quad i = 1,2,\ldots,NG \tag{13}$$

$$V_{Gi,\min} \leqq V_{Gi} \leqq V_{Gi,\max} \quad i = 1,2,\ldots,NG \tag{14}$$

$$T_{i,\min} \leqq T_i \leqq T_{i,\max} \quad i = 1,2,\ldots,NT \tag{15}$$

$$Q_{Ci,\min} \leqq Q_{Ci} \leqq Q_{Ci,\max} \quad i = 1,2,\ldots,NC \tag{16}$$

$$V_{PQi,\min} \leqq V_{PQi} \leqq V_{PQi,\max} \quad i = 1,2,\ldots,NPQ \tag{17}$$

$$Q_{Gi,\min} \leqq Q_{Gi} \leqq Q_{Gi,\max} \quad i = 1,2,\ldots,NG \tag{18}$$

$$S_{Lk,\min} \leqq S_{Lki} \leqq S_{Lk,\max} \quad i = 1,2,\ldots,NE \tag{19}$$

Reactive power constraint of SVC

$$-200\text{MVAR} < Q_{svci} < 200\text{MVAR} \; i \in N_{SVC} \tag{20}$$

Reactance constraint of TCSC

$$-0.5X_L < X_{TCSCi} < 0.5X_C \;\; i \in N_{TCSC} \tag{21}$$

The control variables used in the multiobjective problem is generator real power settings (PG*i*) and voltage settings(VG*i*), transformer tap settings (T*i*),reactive power compensation setting(Q*ci*). VPQ*i* Voltage at PQ bus, SL*k* is k^{th} line apparent power. Max and min represents maximum and minimum control variables value. Total numbers of generators(NG), transformers(NT), switchable VAR sources(NC), and PQ buses(NPQ).

3. PROPOSED APPROACH FOR STABILITY

Particle swarm optimization (PSO) : PSO is used to resolve engineering based optimization problems, this algorithm used population based tool. The flocking birds behavior is based on PSO. The swarm fly of this birds randomly move to the food position. In the same way candidates solution is called as particles (total population), In each iteration the position is relocated and updated with time to find the optimal solution in that search space. The velocity is adjusted with own and companions flying experience. The best solution (fitness) is named Pbest, Gbest is the overall global best value. The updation of velocity and position is in the below equation.

$$\begin{aligned} v_i(t+1) &= \omega \,.\, v_i(t) + c_1 \,.\, r_1 \,.\, [\mathrm{P}_{\mathrm{besti}}(t) - x_i(t)] + c_2 \,.\, r_2 \,.\, [\mathrm{Rep}_j(t) - x_i(t)] \\ x_i(t+1) &= x_i(t) + v_i(t+1) \end{aligned} \tag{22}$$

t is iterations, x_i is i^{th} particle position, Vi is i^{th} particle velocity, w inertia weight, The acceleration constants are c_1, c_2. Random numbers are r_1 and r_2, The best global(Gbest) value is Rep j, roulette-wheel and random selection method is used to determine the index j.

The MOPSO is used for multi objective optimization(MOO) problem. Due to the Pareto fronts bad diversity and premature convergence we will go for Hybrid MOPSO.

In this HMOPSO incorporated by Gaussian probability distribution, time variant acceleration coefficient, chaotic descending inertia weight, self-adaptive mutation operators, and dynamic crowding distance, which are explained below in detail. G1, G2 are expressed as *Gaussian Distributed Random Numbers* shown below updated equation.

$$v_i(t+1) = \omega \,.\, v_i(t) + c_1 \,.\, \mathrm{G}_1 \,.\, [\mathrm{P}_{\mathrm{besti}}(t) - x_i(t)] + c_2 \,.\, \mathrm{G}_2 \,.\, [\mathrm{Rep}_j(t) - x_i(t)] \tag{23}$$

Chaotic inertia weight approach $c\omega_t$ is defined as

$$\begin{aligned} \omega_t &= \omega_{\max} + (\omega_{\max} - \omega_{\min}) \times \\ c\omega_t &= \omega_t \times \gamma_t, \frac{t}{t_{max}} \end{aligned} \tag{24}$$

$c\omega_t$ is t^{th} iteration chaotic weight, the t^{th} iteration weight factor is wt, The t^{th} iteration weight factor, and t^{th} iteration chaotic parameter variable is γ_t, γ_t formula is

$$\gamma_t = u \times \gamma_{t-1} \times (1 - \gamma_{t-1}), \tag{25}$$

where control parameter is u. $t-1^{\mathrm{th}}$ iteration chaotic parameter variable is γ_{t-1}.

Time Variant Acceleration Coefficients : The value of c_1 is allowed to decrease linearly with iteration from $c_{1,i}$ to $c_{1,f}$ and the value of c_2 is allowed to increase linearly with iteration from $c_{2,i}$ to $c_{2,f}$ described as follows:

$$\begin{aligned} c_{1,t} &= c_{1,i} + (c_{1,f} - c_{1,i}) \,.\, \frac{t}{t_{max}} \\ c_{2,t} &= c_{2,i} + (c_{2,f} - c_{2,i}) \,.\, \frac{t}{t_{max}} \end{aligned} \tag{26}$$

Self-adaptive mutation parameters and Dynamic crowding distance parameters also added in HMOPSO.

HMOPSO algorithm used to solve CM problem in IEEE30-bus power systems and the results are compared with existing popular algorithms, MOPSO, NSGA-II, and other previous methods. These techniques developed in Matrix laboratory (MATLAB) with necessary alterations in Matpower 4.1 coding. The optimal parameters of these algorithms are below, In IEEE30-bus system, the $\mathrm{N}_{\mathrm{pop}}$ the population size is 50 and maximum iteration is 100.The parameters of the stopping criteria $\delta_{\lim}$ and L are set as 0.01 and 30. The other parameters are

1. **HMOPSO :** Inertia weight $\omega_{\max} = 0.7$, $\omega_{\min} = 0.4$; acceleration constants $c_{1,i} = c_{2,f} = 2.5$, $c_{1,f} = c_2$, $i = 0.5$; chaotic control parameters $u = 4$, $\gamma_0 = 0.48$;
2. **MOPSO :** $w = 0.729$; $c_1 = c_2 = 2.05$; Ngrid = 50;
3. **NSGA-II:** $pc = 0.9$; $pm = 1/n$, pc – crossover probability, pm–mutation probability, number of decision variable is n; the distribution indices for crossover $\eta_c = 20$ and mutation operator $\eta_m = 20$;

The HMOPSO proposed flowchart is shown in the Figure 3.

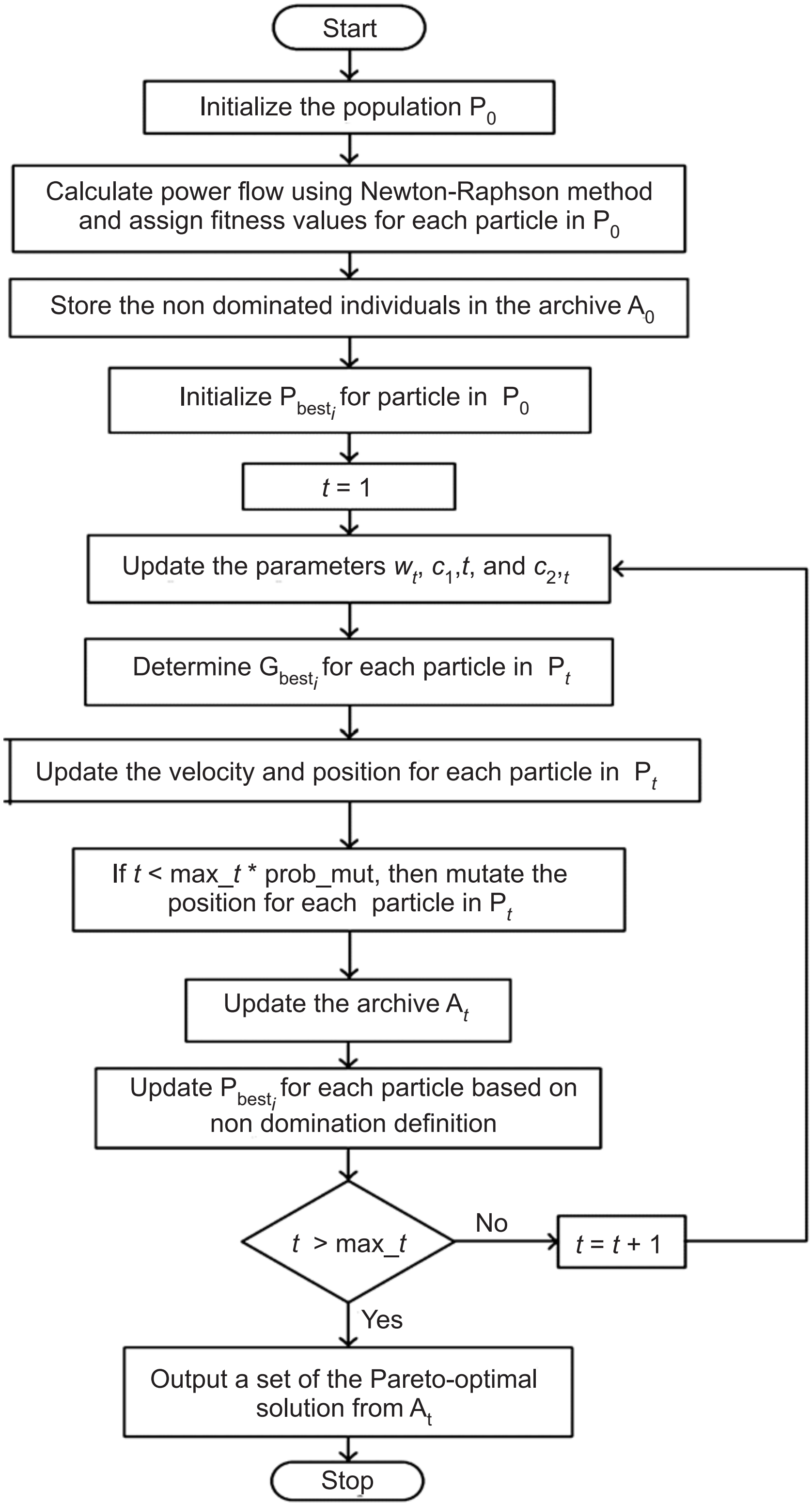

Figure 3: Flowchart for proposed HMOPSO algorithm

4. POWER SYSTEM STUDY IN IEEE30 BUS SYSTEM

The standard IEEE30-bus test system contains 6 numbers of generator, 4 numbers of transformer, 3 numbers of VAR compensator. The total numbers of optimal control variables are 19.The four numbers of transformer tap settings connected between the lines (6-9), (6-10), (4-12), and (27-28) and it is in the range of [0.9 to 1.1] with the steps in 0.0125. Three numbers of VAR compensator in the buses 3, 10 & 24 within the range of [0-20] MVAr with the steps in 1 MVAr. The Slack bus is number 1. The generators (PV buses) are located in the buses 2, 5, 8, 11, and 13, remaining buses are load bus(PQ bus). The range of voltage maintained in the PV buses is 0.95 to 1.1pu and 0.9 to 1.05 for PQ buses.Figure4 shows the ieee30 bus system.

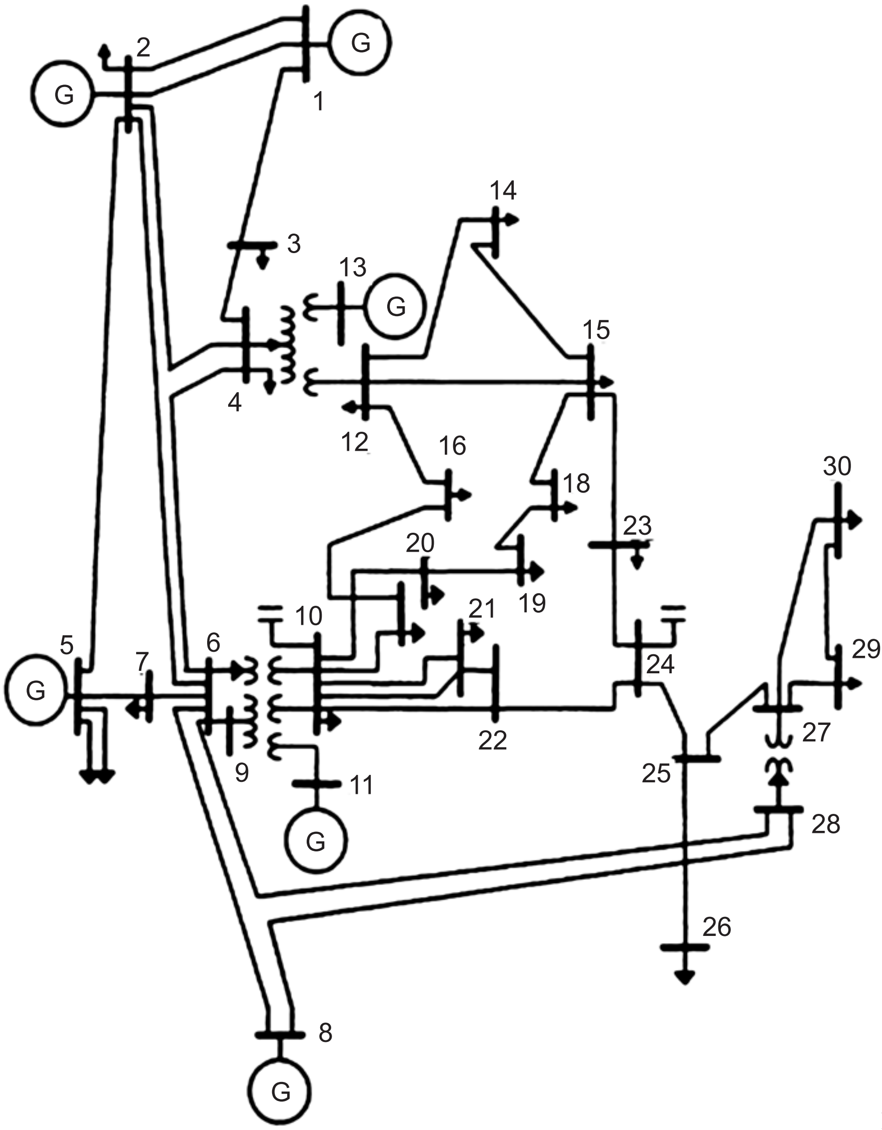

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Figure 4: IEEE30 test bus system

5. CONGESTION MANAGEMENT IN THE POWER SYSTEM AND RESULTS DISCUSSION

Under normal loading condition the system is in stable condition. Here we consider two cases for congestion management in the ieee30 bus test system.

Case 1: Heavy loaded condition.

Case 2: Contingency state with heavy loaded condition.

Here three objective functions considered that is social welfare maximization, minimization of real power loss and voltage stability index(Lindex). This multi-objective problem optimized using algorithms NSGA II, MOPSO, HMOPSO the results are tabulated without FACTS devices and with FACTS devices SVC&TCSC. The proposed algorithms HMOPSO, MOPSO and NSGA-II each case has 25 independent random runs for different algorithms. The location of FACTS devices based on modal analysis.

Case 1: In IEEE30 bus system the load of each bus increased uniformly 125% of normal load condition. The SVC device is located in buses 26, 29 and 30. TCSC located in between the lines 24–26, 27–29 and 24–25. The best Pareto fronts obtained out of 25 runs using HMOPSO, MOPSO and NSGA-II, shown in Fig. 5.The comparative results are tabulated in the table 1. The results of Total social welfare (TSW), Real power loss(P_L) and L-index values are compared and the proposed HMOPSO provides a best result as compared other algorithms shown in figure5.

Table 1

The optimal control variables for minimization of TSW, P_l and L_{max} in IEEE30-bus test system (heavy loaded case)

Control Variable	*Initial*	*Heavy loaded condition*						
		125% Over loaded case	*NSGA II*		*MOPSO*		*Hybrid MOPSO*	
			Without FACTS	*With FACTS (SVC & TCSC)*	*Without FACTS*	*With FACTS (SVC & TCSC)*	*Without FACTS*	*With FACTS (SVC & TCSC)*
P1(MW)	164.8	177.8	143.4	173.07	154.4	170.5	159.6	168.07
P2(MW)	71.7	78.3	46.57	61.17	54.23	48.3	49.6	64.67
P5(MW)	38.8	34.01	25.02	32.94	28.02	24.28	29.16	32.14
P8(MW)	23.6	44.54	42.87	31.57	46.17	30.33	44.88	44.5
P11(MW)	30.8	44.04	23.46	36.25	28.1	25.52	30.1	38.3
P13(MW)	33.6	32.73	41.14	28.79	44.14	42.39	38.16	34.4
VG1(pu)	1.066	0.984	1.016	1.024	0.994	1.014	1.018	1.028
VG2(pu)	1.041	0.966	1.004	1.016	1.004	1.016	1.021	1.032
VG5(pu)	1.052	0.947	0.968	0.982	0.968	0.982	0.968	0.982
VG8(pu)	1.071	0.996	0.991	1.01	1.002	1.012	0.991	1.042
VG11(pu)	1.028	0.913	0.994	1.031	1.008	1.011	1.022	1.028
VG13(pu)	1.053	0.953	0.964	0.992	0.99	1.01	1.016	1.032
T6-9	0.982	1.005	0.967	0.983	0.962	0.971	0.982	0.998
T6-10	1.007	1.041	1.055	1.006	1.05	1.026	1.025	1.035
T4-12	0.974	1.001	0.983	0.982	0.973	0.986	0.988	1.006
T27-28	0.988	0.973	0.977	1.03	0.988	1.028	0.964	1.036
Q3	12.14	10.69	14.12	13.28	12.03	10.02	13.28	11.96
Q10	14.47	8.96	10.02	8.04	16.04	12.6	8.04	12.28
Q24	14.14	12.74	12.68	14.9	7.47	14.1	14.9	17.03
P_L(MW)	5.28	8.86	7.32	6.69	6.88	6.56	6.32	5.98
L-index (L_{max})	0.242	0.426	0.401	0.386	0.379	0.326	0.362	0.318
TSW($/*h*)	1248.6	1640	1507.9	1456	1494	1412	1450.2	1388.4

Case 2: In this case with the heavy loaded condition the N-1analysis also be done. The worst line will be found based on voltage stability index. The line between the buses 27-28 found as worst line and consider it for analysis. Make that line as outage from the active power system the best optimized solution will be found with FACTS and Without FACTS devices by using the algorithms NSGA II, MOPSO and HMOPSO. In IEEE30 bus system the locations of SVC device located in the buses 26, 29 and 30. TCSC located in between the lines 24–26, 27–29 and 24–25. Best Pareto fronts obtained out of 25 runs using HMOPSO, MOPSO and NSGA-II.The comparative results are tabulated in the table 2. The results of Total social welfare (TSW), Real power loss(P_L) and L-index values are compared the proposed HMOPSO

provide a best result as compared other algorithms. The voltage levels of each bus at contingency state, NSGA II with FACTS devices, MOPSO with FACTS devices and HMOPSO with FACTS devices are compared. HMOPSO with FACTS devices provide a best result and bus voltages maintained within limit. Voltage levels are improved and shown in Fig.6.

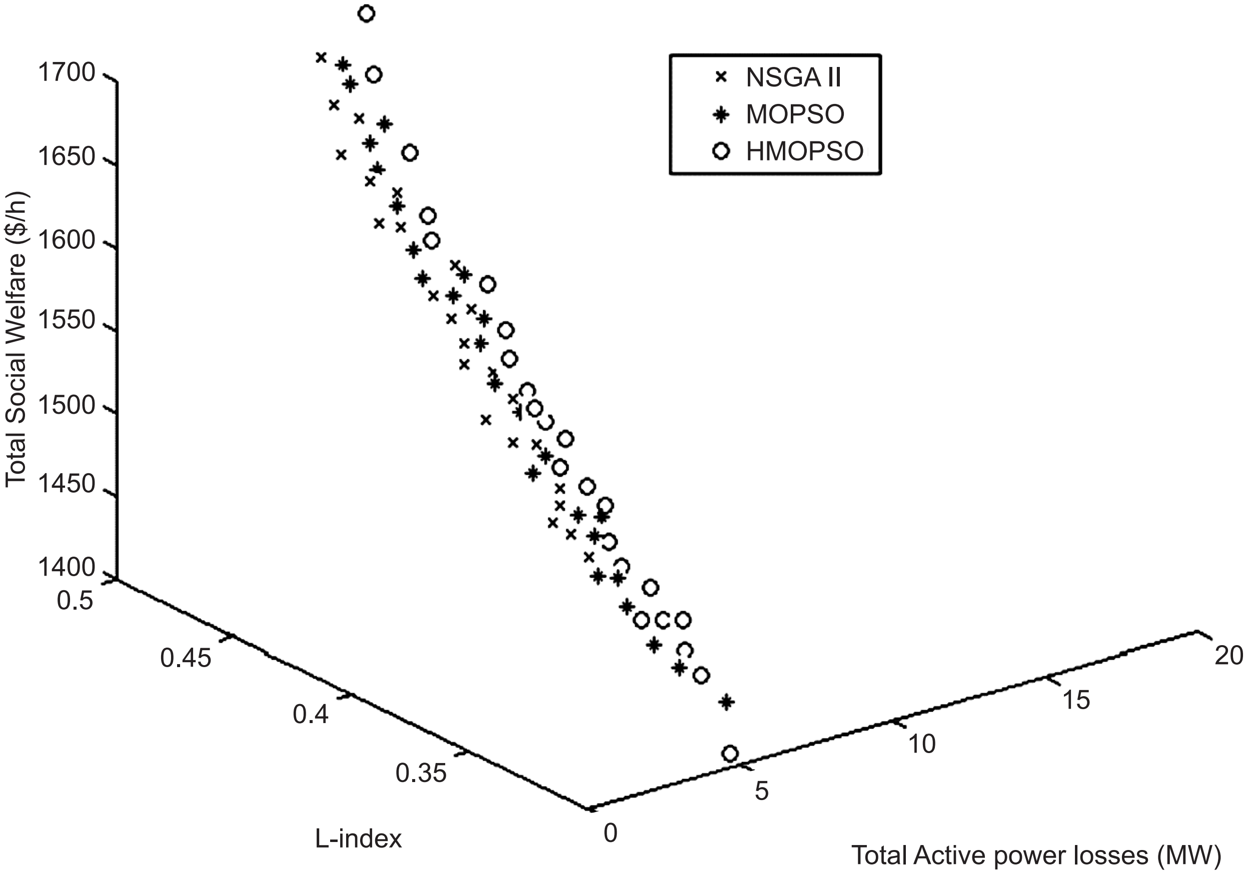

Figure 5 : Best Pareto fronts obtained using HMOPSO,MOPSO and NSGA-II(Heavy load case)

Table 2

The optimal control variables for minimization of TSW, P_L and L_{max} in IEEE30-bus test system (Heavy loaded with contingency state)

Objective	*Initial*	*Contingency state with 125% overloaded condition*						
		Line outage at (27-28) with 125% overloaded condition	*NSGA II*		*MOPSO*		*Hybrid MOPSO*	
			Without FACTS	*With FACTS (SVC& TCSC)*	*Without FACTS*	*With FACTS (SVC& TCSC)*	*Without FACTS*	*With FACTS (SVC& TCSC)*
P_L(MW)	5.28	12.34	11.32	10.94	11.02	9.46	9.32	8.87
L-index (L_{max})	0.242	0.488	0.412	0.322	0.372	0.298	0.302	0.282
TSW($/*h*)	1248.6	1788	1542	1530	1502	1432.4	1488.2	1420.5

6. CONCLUSION AND FUTURE WORK

In this research work, a multiobjective Congestion management problem solved for considering three Different objective functions, that is Minimization of real power loss, Social welfare maximization, and voltage stability enhancement. These multi-objective functions solved using a new HMOPSO algorithm with SVC & TCSC FACTS devices. It is proposed by incorporating and modifying a Gaussian probability distribution, self-adaptive mutation operator, time variant acceleration coefficients, chaotic descending inertia weight, and dynamic crowding distance into the classical MOPSO. The multi-objective congestion management solved using new approach in the IEEE30-bus systems, under both heavy load and contingency states. The results of the existing popular algorithms NSGA-II, MOPSO and HMOPSO are compared with and without FACTS devices. The results shows that the superiority of HMOPSO in terms of solution quality and computational efficiency and confirm its potential for the CM problem in Deregulated power system. In Future results will be compared with other recent algorithms. Work out the same in different FACTS devices and higher IEEE test bus systems.

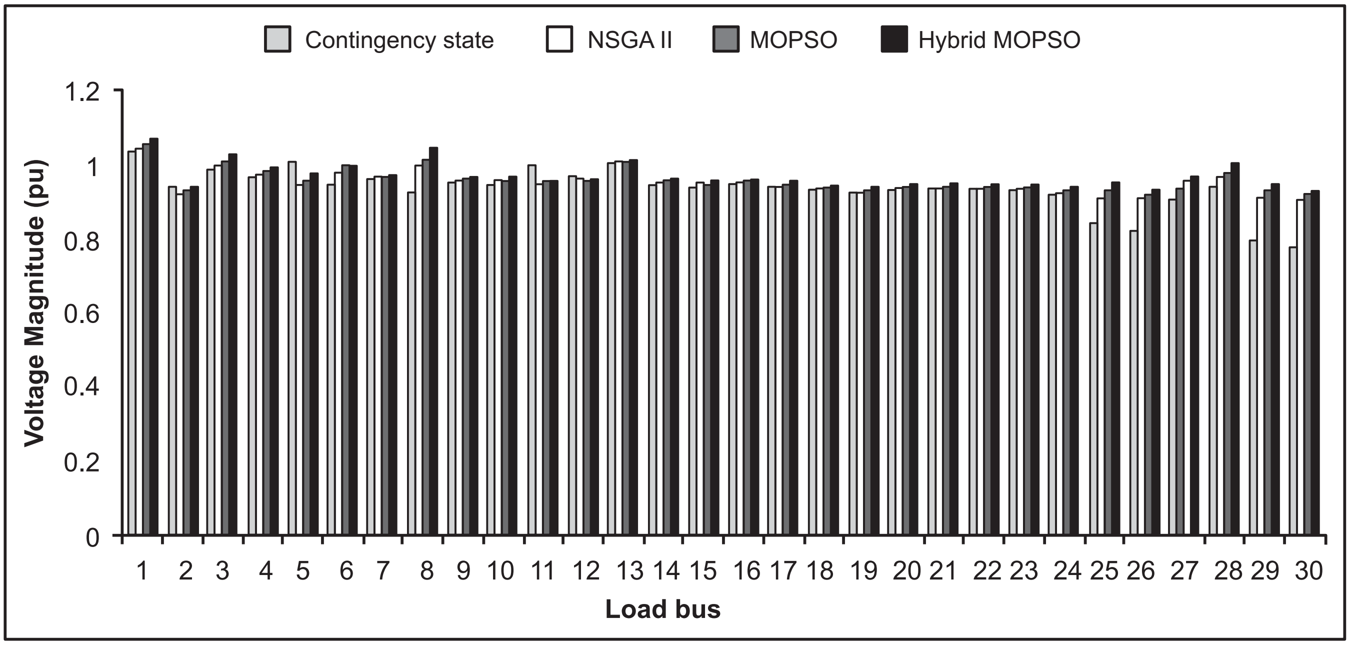

Figure 6: Comparative voltage levels for bus Vs Voltage Magnitude (pu) (contingency state)

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