International Journal of Research in Advent Technology, Vol.4, No.4, April 2016
E-ISSN: 2321-9637
Available online at www.ijrat.org

Unit Commitment Using Hybrid Gravitational Search Algorithm

Shivani Mehta[1], Gourav Kumar[2]
Assistant Professor[1], Student, Master of Technology[2]
Department of Electrical Engineering, D.A.V.I.E.T., Jalandhar, Punjab, India 1, 2
Email:shivanimehta7@gmail.com[1],kgourav170@yahoo.com[2]

Abstract: -An imperative condition in power system process is to meet the power demand at least fuel cost using the most favourable combination of diverse power plants. Unit Commitment is the predicament of defining the list of generating units focus to device and operating constraints. The design of unit commitment has been conversed and the result is got by hybrid gravitational search algorithm (HGSA). An algorithm based on hybrid gravitational search technique, which is aninhabitants based global search and optimization procedure has been established to resolve the unit commitment problem. The efficiency of these algorithms has been finding by compare four units and ten units of system.

Keywords: Unit Commitment, particle swarm optimization (PSO), gravitational search algorithm (GSA), Hybrid Gravitational Search Algorithm (HGSA).

1. INTRODUCTION

Electrical power plays a fundamental role in the contemporary world to convince various needs. It is therefore very imperative that the electrical power generated is transmitted and distributed resourcefully in order to satisfy the power requirement. Electrical power is generated in several traditions. The economic scheduling of all generators in a system to meet considered necessary demand is important problem in operation and planning of power system. Unit commitment (UC) is a nonlinear mixed integer optimization dilemma to schedule the procedure of the producing unit's at least working price while rewarding the demand and other equality and disparity constrains [1]. The UC problem has to resolve the on/off state of the producing units at each hour of the scheduling dated and optimally transmit the load between the devoted units.

Researchers studied this composite quandary for eras and many old-style techniques have been developed.The traditional techniques include priority list method [1-2], integer programming (IP) [3], dynamic programming (DP) [4–6], branch and bound [7], Benders' de-composition [8] and Lagrangian relaxation (LR) [9– 11]. Amid these methods, the priority list method is one of the initial and humblest methods to discourse the UC problem. Dynamic programming is one of the techniques to solve UC problem, but it suffer from problem of annoyance of dimensionality. Due to the high involvedness and high nonlinearity of the UC problem, simulated intellect approaches are used as asubstituteto conventionaldiagnostic approaches in topical times. These methods have the benefit of examining the result space more painstakingly. Numerous simulated intellect approaches, such as Tabu search (TS) [12], simulated annealing (SA) [13–15], evolutionary programming (EP) [16], genetic algorithm (GA) [17–19], artificial neural networks (ANN) [20], particle swarm optimization (PSO) [21], hybrid PSO (HPSO) [22], and ant colony optimization (ACO) [23] have been developed and applied successfully to UC problems.The GSA, one of the most up-to-date heuristic algorithms inspired by the Newton laws of gravity and motion, was established by Rashedi et al. [24].In the year of 2009.This paper suggests a hybrid UC (HUC) formulation that combines the PSO and GSA formulations with the aim of achieving a solution that balances the operating cost and forcefulness.

2. PROBLEM FORMULATION

The objective function of the UC problem is to minimize the total generation cost while satisfying the different constraints, when the required load of power system is being supplied. The objective function to be minimized is given by the following equation:

Minimize $F(P_{gi)} = \sum a_i P_{gi}^2 + b_i P_{gi} + c_i$Rs/hr

where i=1 to N

The overall fuel cost has to be reduced with the following constraints:

1) Power balance constraint

The total generation by all the generators must be equivalent to the total power ultimatum and system's real power loss.

$$\sum P_{ih} U_{ih} = D_h \quad i=1, 2\ldots N$$

2) Generator limit constraint

The real power generation of each generator is to be controlled inside its particular upper and lower operating limits.

$P_{gi}^{min} \leq P_{gi} \leq P_{gi}^{max}$ i=1,2………,ng.

3) Lowest up time constraint

On one occasion a unit is started up, it should not be shut-down before a least up-time period is met and it scientificallyarticulated for i^th generating unit as follows:

$$T_i^{ON} \geq T_i^{UP}$$

4) Lowest down time constraint

Once a unit is started downcast, it should not be shut-up before a least down-time period is met and it accuratelyuttered for i^th generating unit as follows:

$$T_i^{OFF} \geq T_i^{DOWN}$$

Where

a_i, b_i, c_i : coefficient of fuel cost of i^th generator, Rs/MW2 h, Rs/MW h, Rs/h

F (Pg): total fuel cost, Rs/h

n: number of generators.

P_{gi}^{min}: Minimum limit of generation for i^th generator, MW

Pgi^{max}: Maximum limit of generation for i^th generator.

T_i^{OFF} is the off time period of the i^th generating unit.

T_i^{DOWN} is the least down time of the i^th generating unit.

T_i^{ON} is the ON time duration of the i^th generating unit.

T_i^{UP} is the minimum up time of the i^th generating unit.

3. THE STANDARD PSO, STANDERD GSA AND HGSA

In this unit, we discuss the algorithm of standard PSO, standard GSA and standard HGSA.

A. Standard particle swam optimization:

The PSO algorithm is constructed on collective performance of bird flocking which is developed by Kennedy and Eberthart [27]. In this algorithm, it consists no of particle which fly in search space to find the finest solution. So particle consider two value which is called pbest and gbest. The PSO are using following exposed.

$$v_i^{t+1} = wv_i^t + c_1 \times rand \times (pbest_i - x_i^t) + c_2 \times rand \times (gbest_i - x_i^t) \quad (1)$$

$$x_i^{t+1} = x_i^t + v_i^{t+1} \quad (2)$$

v_i^t is velocity of particle i^th, rand is random variable (0,1). w is weighting function, c_j is a weighting factor. x_i^t is the position of the particle i^th. . $pbest_i$ is the best value of particle i^th and gbest is the best value of global.

B. Standard gravitational search algorithm:

GSA was announced by Rashedi et al. in 2009 and is predicted to resolve optimization difficulties. The population-based heuristic algorithm is based on the gravity law and mass interactions [24]. The algorithm is included of assortment of forager agents that interconnect with each other through the gravity force. The agents are measured as objects and their performance is measured by their masses. The gravity force sources a universal measure where all objects move near other objects with heavyweight masses.

The GSA are using following modeled. Consider a system has N agents and procedure starts with arbitrarily placing all agent in search space. The gravitational force which performing on the i^th object due to the j^th object is given below:

$$F_{ij}^d(t) = G(t) \times \left(\frac{M_j(t) - M_i(t)}{R_{ij}(t) + \in} \right) \times \left(x_j^d(t) - x_j^d \right) \quad (3)$$

G (t) stand for the gravitational constant which is adjusted at the initial and it regulate the searching ability of the objects with decreases the time.

$$G(t) = G_0 e^{(-\alpha t/T)} \quad (4)$$

Where G_0 stand for the initial value of gravitational constant, and $Iter^{max}$ stand for the total number of iterations. α stand for a constant value The total force performing on the i^th agent is represented by:

.

$$F_i^d(t) = \sum_{j=1, j \neq i}^{k_{best}} rand_j \times F_{ij}^d(t) \quad (5)$$

According to gravitational law, the acceleration of the i^th agent at the t^th iteration in d^th direction, is recognized by:

$$a_i^d(t) = F_i^d(t) / M_{ii}(t) \quad (6)$$

The updated velocity of an agent is calculated and this updated velocity is added into its acceleration which is given below equation (7). Consequently, the updated position and the velocity of the i^th agent at the t^th iteration, in d^th direction may be expressed as follows:

$$v_i^d(t+1) = rand_i \times v_i^d(t) + a_i^d(t) \quad (7)$$

$$x_i^d(t+1) = x_i^d(t) + v_i^d(t+1) \quad (8)$$

C. Standard hybrid gravitational search algorithm (HGSA):

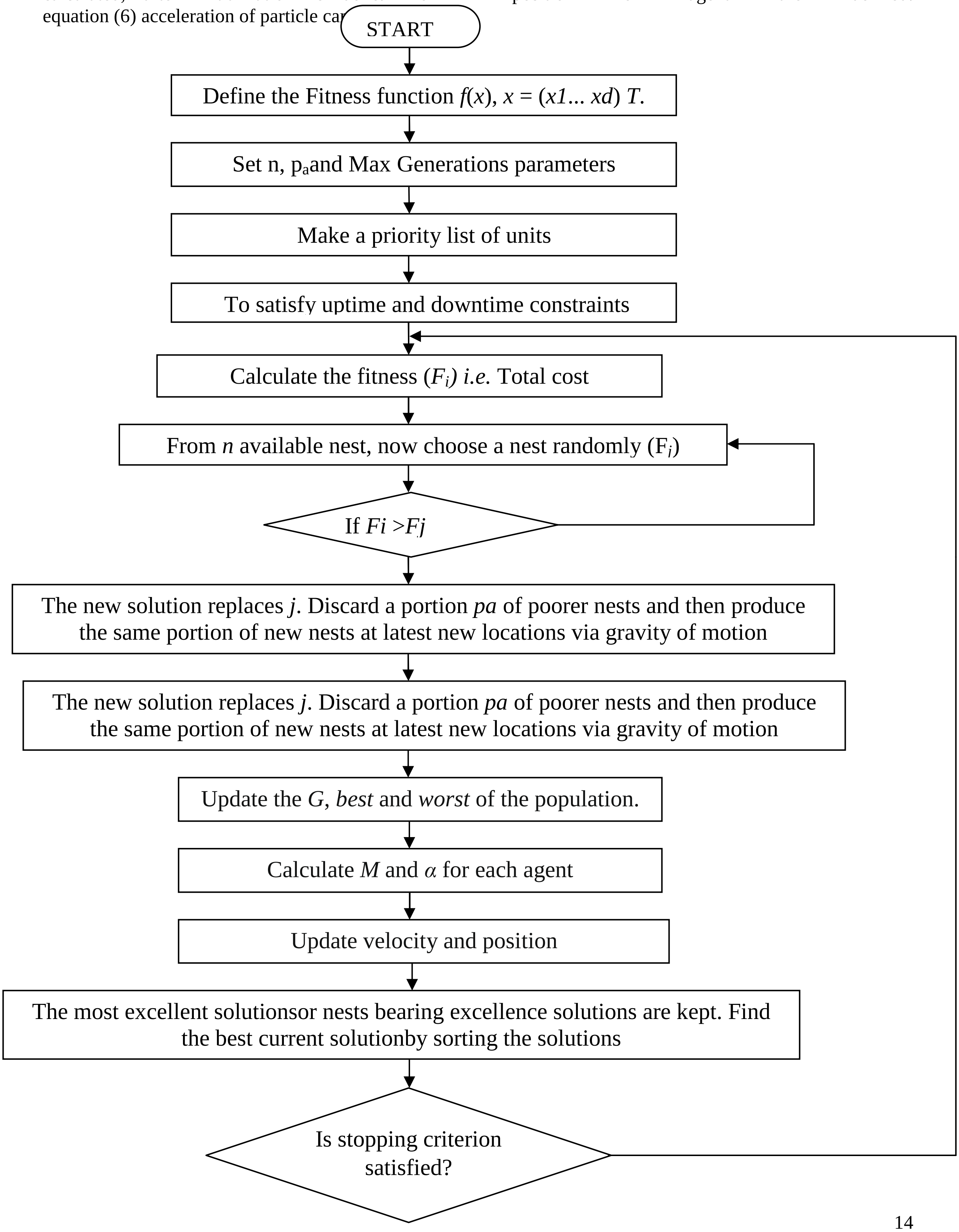
In this paper, we combine PSO with GSA. Both are working in analogous.it is varied because there are two altered algorithm that are elaborate to yield ultimate result. The elementary idea of PSOGSA is to association the exploration skill of PSO with exploitation search capability of GSA.

$$v_i(t+1) = w \times v_i(t) + c_1' \times rand \times ac_i(t) + c_2' \times rand \times (gbest - X_i(t)) \quad (9)$$

$$x_i(t+1) = X_i(t) + V_i(t+1) \quad (10)$$

v_i^t is velocity of particle i^th, rand is random variable (0,1). w is weighting function, c_j is a weighting factor and gbest is the best value of global. All the agent are randomly initialize in

PSOGSA method and each agent is considered as candidate solution. Using equation (3), (4) and (5) gravitational force, gravitational constant and resultant forces among agent respectively are calculated, after initialization is done. From equation (6) acceleration of particle ca after all iteration finest answer should be efficient. The velocity of agent can be calculated from equation (9), using calculated acceleration and updated best solution. From equation (10) final position of agent are defined.



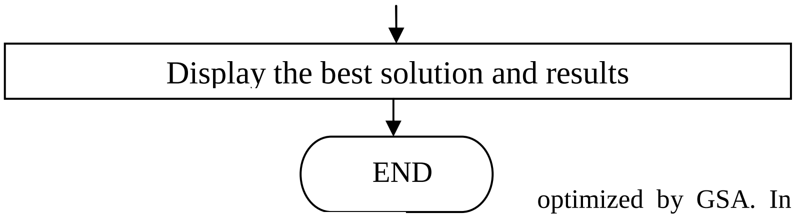


Figure 1 Flow chart of GSA

4. HGSA APPROACH TO UC

The innovative description of PSO [21] operates on real values. First "hybrid particle swarm optimization" was developed in [22], whereby the term hybrid meant the amalgamation of PSO and GA. On the other hand, in this paper, hybrid is intended to emphasize the perception of permutation real valued PSO with GSA running autonomously and concurrently. The HGSA is made promising with a straightforwardadaptation to the particle swarm algorithm. This HGSA solves binary strugglecomparable to those conventionally optimized by GSA. In our grades to resolve the UC, The results of HGSA compare with result of GSA.We proved that the results of HGSA better than GSAin the feasible environment.

5. RESULTS & DISCUSSIONS

HGSA has been used to resolve the UC problems in two different test cases for exploring its optimization potential, where the objective function was imperfect inside power ranges of the producing units.

5.1 Test system I: The input data for four generators is derivative from reference [09] and is given in table 1 and table 2.The unit commitment (UC) for 4 generators is solved with HGSA and results are compared with GSA.

Table 1: Data of the 4 unit system [09]

Parameters	Unit 1	Unit 2	Unit 3	Unit 4
Pmax (MW)	300	250	80	60
Pmin (MW)	75	60	25	20
a ($/hr)	684.74	585.62	213.00	252.00
b($/MWhr)	16.83	16.95	20.74	23.60
c ($/MW2hr)	0.0021	0.0042	0.0018	0.0034
Min up time (hr)	5	5	4	1
Min down time(hr)	4	3	2	1
Hot start-up cost ($)	500	170	150	0
Cold start-up cost ($)	1100	400	350	0.02
Cold start-up hrs(hr)	5	5	4	0
Initial status (hr)	8	8	-5	-6

Table 2: Load pattern of the 4 unit system

Hour(h)	1	2	3	4	5	6	7	8
Load(MW)	450	530	600	540	400	280	290	500

5.2 GSA Algorithm Results: The outcomes acquired for the test system using GSA programming are given below in Table 3.

Table 3: GSA Result of 4 unit system

S.No	**Load**	**Unit Mixture Selected**	**Load delivered Between The Units (MW)**				**Total Production Cost (Rs)**
1	450	1 1 1 1	151	131	91	78	1206.049
2	530	1 1 1 0	257	225	47	0	2339.495
3	600	1 1 1 1	171	183	132	114	2010.307
4	540	1 1 1 0	223	243	73	0	2267.110
5	400	1 1 0 1	223	141	0	35	1452.380
6	280	1 1 0 0	141	139	0	0	840.5792
7	290	1 1 1 1	122	115	26	28	667.6147
8	500	1 1 1 1	226	146	71	57	1672.091

Total Operating Cost	12455.6259

5.3 Hybrid GSA Algorithm Results: The results obtained for the test system using HGSA programming are summarized below in Table 4.

Table 4: HGSA Result of 4 unit system

S.No	Load	Unit Mixture Selected	Load delivered Between The Units (MW)				Total Production Cost (Rs)
1	450	1 1 1 1	136	198	69	47	1363.799
2	530	1 1 1 1	236	106	114	74	1793.879
3	600	1 1 1 1	278	163	76	84	2361.210
4	540	1 1 1 1	172	164	135	70	1708.314
5	400	1 1 1 1	207	100	53	40	1209.030
6	280	1 1 1 1	122	107	16	35	637.8953
7	290	1 1 1 1	163	64	28	36	728.2475
8	500	1 1 1 1	175	185	56	84	1589.050
Total Operating Cost							11391.4248

Table 5 Comparison of result of two methods for 4 units

Method	Total Operating Cost (Rs)
GSA	12455.6259
Hybrid GSA	11391.4248

The comparison of the proposed method is revealed above in the table which displays that the total operating cost of hybrid GSA is less with Gravitational search algorithm (GSA) method for unit commitment.

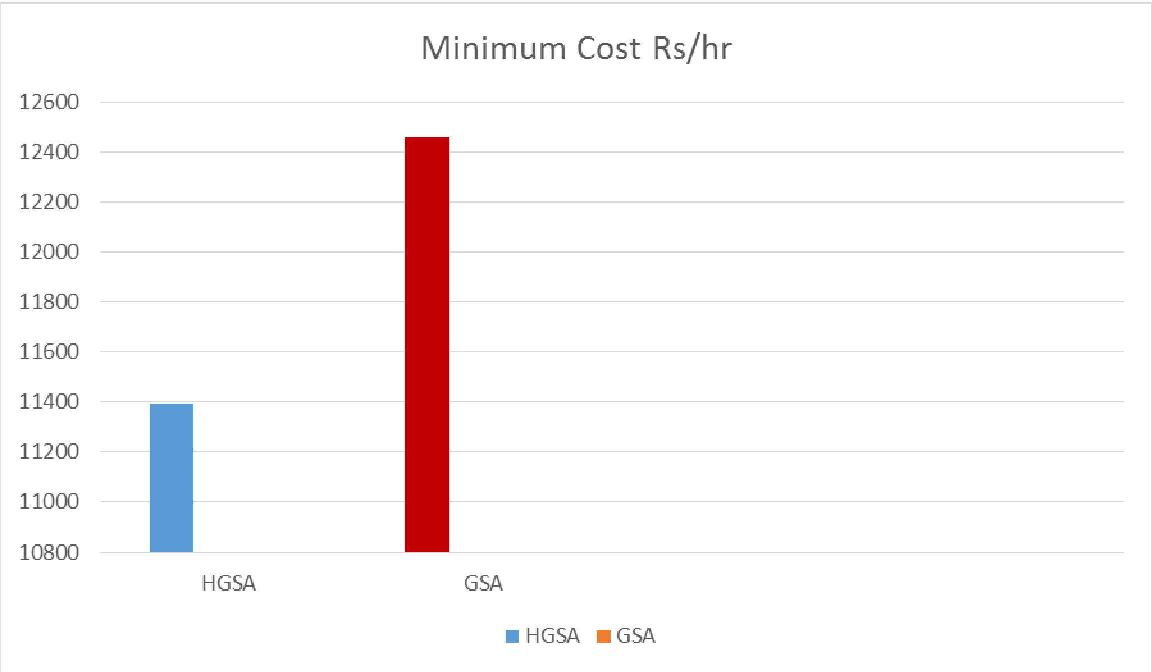


Figure 2 Comparison results of Hybrid GSA and GSA for 4-unit system

5.4 Test system II: The input data for ten generators is derived from reference [09] and is given in table 6 and table 7.The unit commitment (UC) for10 generators is solved with HGSA and results are compared with GSA.

Table 6: Data of the 10 unit system [09]

Parameters	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Pmax (MW)	455	455	130	130	162
Pmin (MW)	150	150	20	20	25
a ($/hr)	1000	970	700	680	450
b($/MWhr)	16.19	17.26	16.60	16.50	19.70
c ($/MW2hr)	0.00048	0.00031	20	0.00211	0.00398
Min up time (hr)	8	8	5	5	6
Min down time(hr)	8	8	5	5	6
Hot start-up cost ($)	4500	5000	550	560	900
Cold start-up cost ($)	9000	10000	1100	1120	1800
Cold start-up hrs(hr)	5	5	4	4	4
Initial status (hr)	8	8	-5	-5	-5

Parameters	Unit 6	Unit 7	Unit 8	Unit 9	Unit 10
Pmax (MW)	80	85	55	55	55
Pmin (MW)	20	25	10	10	10
a ($/hr)	370	480	660	665	670
b($/MWhr)	22.26	27.74	25.92	27.27	27.79
c ($/MW2hr)	0.00712	0.00079	0.00413	0.00222	0.00173
Min up time (hr)	3	3	1	1	1
Min down time(hr)	3	3	1	1	1
Hot start-up cost ($)	170	260	30	30	30
Cold start-up cost ($)	340	520	60	60	60
Cold start-up hrs(hr)	2	2	0	0	0
Initial status (hr)	-3	-3	-1	-1	-1

Table 7: Load pattern of the 10 unit

Hour(h)	**Load(MW)**	**Hour(h)**	**Load(MW)**	**Hour(h)**	**Load(MW)**
1	700	9	1300	17	1000
2	750	10	1400	18	1100
3	850	11	1450	19	1200
4	950	12	1500	20	1400
5	1000	13	1400	21	1300
6	1100	14	1300	22	1100
7	1150	15	1200	23	900
8	1200	16	1050	24	800

5.5 GSA Algorithm Results: The outcomes acquired for the test system using GSA are shown in Table 8.

Table 8: GSA result of 10 unit system

S.No	Load	Unit Mixture Selected	Load delivered Between The Units (MW)										Total Production Cost (R)
1	700	1 1 0 1 1 0 0 1 1 0	254	170	0	118	96	0	0	41	21	0	2606.441
2	750	1 1 0 1 1 0 0 0 0 1	330	264	0	60	54	0	0	0	0	43	3811.724
3	850	1 1 0 1 1 0 0 0 0 0	266	374	0	98	111	0	0	0	0	0	4712.660
4	950	1 1 0 1 1 1 0 0 0 1	273	368	0	90	108	74	0	0	0	36	4863.662
5	1000	1 1 0 1 1 1 0 0 0 0	284	476	0	52	150	38	0	0	0	0	6598.039

6	1100	1 1 1 1 1 1 0 1 1 0	345	392	25	91	134	76	0	13	24	0	6150.900
7	1150	1 1 1 1 1 1 1 0 0 0	286	471	76	44	127	102	44	0	0	0	6826.617
8	1200	1 1 1 1 1 1 1 1 0 0	341	354	163	90	71	39	68	76	0	0	6005.782
9	1300	1 0 1 1 1 1 1 1 1 0	500	0	156	153	190	105	52	73	71	0	7107.698
10	1400	1 0 1 1 1 1 1 0 0 0	627	0	231	192	63	163	124	0	0	0	10026.460
11	1450	1 0 0 1 1 1 1 0 0 1	573	0	0	243	218	176	155	0	0	85	9820.579
12	1500	1 0 0 1 1 1 1 1 0 1	538	0	0	187	210	165	146	113	0	140	9277.287
13	1400	1 0 0 1 0 1 1 0 1 1	615	0	0	322	0	231	111	0	78	44	10629.750
14	1300	1 0 0 1 0 1 1 1 1 0	685	0	0	157	0	203	176	28	51	0	10883.140
15	1200	1 0 0 1 0 1 1 0 0 0	746	0	0	158	0	109	187	0	0	0	11638.590
16	1050	1 0 0 1 0 1 0 0 0 1	786	0	0	85	0	75	0	0	0	104	11479.900
17	1000	0 1 0 1 0 1 0 1 0 0	0	522	0	157	0	184	0	137	0	0	7127.732
18	1100	0 1 0 1 0 1 0 0 0 1	0	758	0	103	0	170	0	0	0	68	11793.850
19	1200	0 1 0 1 0 1 0 0 1 0	0	668	0	410	0	69	0	0	45	0	11740.420
20	1400	0 1 0 1 0 1 0 0 0 1	0	702	0	387	0	200	0	0	0	111	13296.780
21	1300	0 1 0 1 0 1 0 1 0 1	0	547	0	438	0	73	0	103	0	140	10275.280
22	1100	0 1 0 1 0 1 1 1 0 0	0	371	0	276	0	173	169	110	0	0	6179.663
23	900	0 1 0 1 0 1 1 1 0 1	0	410	0	91	0	119	94	47	0	79	5428.016
24	800	0 1 0 1 0 1 1 0 1 0	0	349	0	184	0	70	122	0	74	0	3937.940
Total Operating Cost													192218.91

5.6 Hybrid GSA Algorithm Results: The results obtained for the test system using HGSA are summarized below in Table 9.

Table 9: HGSA result of 10 unit system

S.No	Load	Unit Combination Selected	Distribution of Load Among The Units (MW)										Total Production Cost (R)
1	700	1 1 1 1 1 0 1 1 1 0	122	208	90	98	114	0	23	19	28	0	2142.324
2	750	1 1 1 1 1 0 1 0 1 1	300	167	97	25	57	0	42	0	21	42	2915.314
3	850	1 1 1 1 1 0 1 0 1 1	292	210	19	104	109	0	53	0	44	20	3400.332
4	950	1 1 1 1 1 1 1 1 1 1	326	194	25	106	109	54	24	23	41	49	3768.642
5	1000	1 1 1 1 1 1 1 0 0 0	344	323	70	78	58	80	47	0	0	0	5007.424
6	1100	1 1 1 0 1 1 1 0 1 0	449	279	82	0	154	35	85	0	16	0	6333.123
7	1150	1 1 1 0 1 0 0 1 1 1	404	274	110	0	195	0	0	57	61	50	6091.034
8	1200	1 1 1 0 1 0 0 1 0 1	315	299	246	0	240	0	0	20	0	80	6430.366
9	1300	1 0 1 0 1 0 0 1 1 0	619	0	139	0	309	0	0	129	104	0	10141.900
10	1400	1 0 1 0 1 1 1 0 1 0	532	0	309	0	215	133	140	0	71	0	9162.777
11	1450	1 0 1 1 1 1 1 0 1 1	557	0	156	259	173	144	75	0	41	46	8914.889
12	1500	1 0 1 1 1 1 1 0 0 1	630	0	292	138	95	115	178	0	0	52	10716.580
13	1400	1 0 1 1 1 0 1 0 1 1	677	0	112	278	152	0	65	0	59	57	10783.900
14	1300	1 0 1 1 1 0 1 1 1 1	402	0	175	63	125	0	203	87	105	140	6625.939
15	1200	1 0 1 1 1 0 1 0 1 0	725	0	99	151	123	0	82	0	20	0	10550.260
16	1050	1 0 0 1 1 0 0 1 1 0	699	0	0	99	110	0	0	81	60	0	9488.837
17	1000	0 1 0 1 1 0 0 1 1 1	0	481	0	132	245	0	0	29	36	77	6452.379
18	1100	0 1 0 1 1 0 0 0 0 1	0	558	0	268	149	0	0	0	0	125	8305.919
19	1200	0 1 0 1 0 1 0 1 0 1	0	639	0	300	0	150	0	64	0	47	10155.060
20	1400	0 1 0 1 0 1 0 1 1 1	0	628	0	285	0	186	0	94	113	94	10812.980
21	1300	0 1 0 1 0 1 0 0 0 0	0	664	0	389	0	247	0	0	0	0	12465.380
22	1100	0 1 0 1 0 0 1 0 0 0	0	757	0	205	0	0	138	0	0	0	12053.380
23	900	0 1 0 1 0 0 1 1 1 1	0	605	0	112	0	0	44	53	38	48	7531.952
24	800	0 1 0 1 0 0 1 1 1 1	0	305	0	182	0	0	150	61	42	61	3625.772
Total Operating Cost													183876.463

Table 10 Comparison of result of two methods for 10 units

Method	Total Operating Cost (Rs)
GSA	192218.91
Hybrid GSA	183876.463

The comparison of the proposed method is shown above in the table which shows that the total operating cost of hybrid GSA is less with Gravitational search algorithm (GSA) method for unit commitment.

6. CONCLUSION

In this paper unit commitment problem (UC) has been solved by using HGSA. The results of HGSA are compared for four and ten generating unit systems with GSA. The algorithm is programmed in MATLAB (R2010b) software package. The results show effectiveness of HGSA for solving unit commitment problem (UC) the problem. The advantage of HGSA algorithm is its simplicity, reliability and efficiency for practical applications.

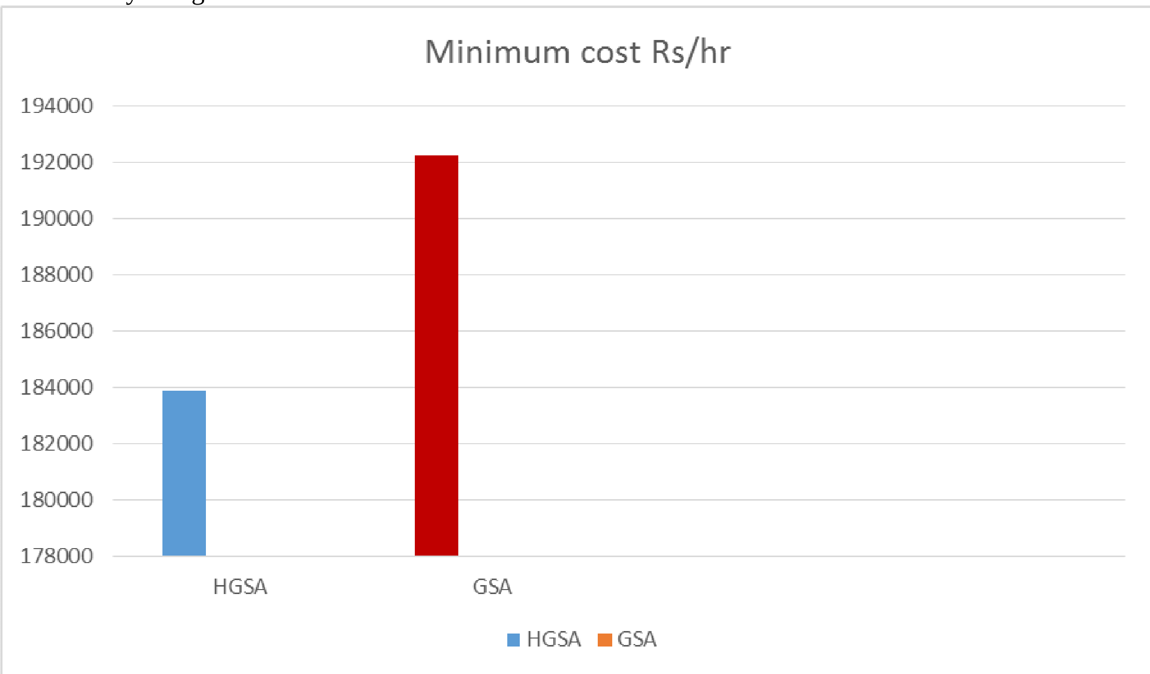


Figure 3 Comparison results of Hybrid GSA and GSA for 10-unit system

REFERENCES

[1]. Burns RM, Gibson CA. Optimization of priority lists for a unit commitment program. In: IEEE Proc PES summer meeting; 1975.
[2].Senjyu T, Shimabukuro K, Uezato K, Funabashi T. A fast technique for unit commitment problem by extended priority list. IEEE Trans Power Syst2003;18(2):882–8.
[3].Lingfeng Wang and Chanan Singh," Unit Commitment Considering Generator Outages through A Mixed-Integer Particle Swarm Optimization Algorithm" IEEE Trans. On Power System, vol.6, 2006.
[4]. Snyder WL, Powell HD, Rayburn JC. Dynamic programming approach to unit commitment. IEEE Trans Power Syst 1987;2(2):339–50.
[5]. Su CC, Hsu YY. Fuzzy dynamic programming: an application to unit commitment. IEEE Trans Power Syst 1991;6(3):1231–7.
[6]. Ouyang Z, Shahidehpour SM. An intelligent dynamic programming for unit commitment application. IEEE Trans Power Syst 1991;6(3):1203–9.
[7]. Cohen AI, Yoshimura M. A branch-and-bound algorithm for unit commitment. IEEE Trans Power ApparatSyst 1983;102(2):444–51.
[8].ShantanuChakraborty,TomonobuSenjyu,Atsusi Yona,Ahmed YousufSaberand Toshihisa Funabashi," Thermal Generation Planning Strategy Facilitating Units Decomposition by Particle Swarm Optimization and Multi-stage

Dynamic Programming" IEEE Trans. On Power System, 2009.

[9]. P. Sriyanyong, and Y.H.Song," Unit Commitment Using Particle Swarm Optimization Combined with Lagrange Relaxation" IEEE Trans. On Power System, vol.5, 2005.

[10].Zhuang F, Galiana FD. Toward a more rigorous and practical unit commitmentby Lagrangian relaxation. IEEE Trans Power Syst 1988;3(2):763–73.

[11]. Ongskul W, Petcharaks N. Unit commitment by enhanced adaptive Lagrangianrelaxation. IEEE Trans Power Syst 2004;19(1):620–8.

[12]. C. ChristoberAsirRajan and M. R. Mohan," An Evolutionary Programming-Based Tabu Search Method For Solving The Unit Commitment Problem" IEEE Trans. On Power System, vol.19, No. 1, 2004.

[13].Zhuang F, Galiana FD. Unit commitment by simulated annealing. IEEE Trans Power Syst 1990;5(1):311–8.

[14]. Wong SYW. An enhanced simulated annealing approach to unit commitment. Int J Electr Power Energy Syst 1998;20(5):359–68.

[15].Mantawy AH, Abel-Mogid YL, Selim SZ. A simulated annealing algorithm for unit commitment. IEEE Trans Power Syst 1998;13(1):197–204.

[16].Juste KA, Kita H, Tanaka E, Hasegawa J. An evolutionary programmingsolution to the unit commitment problem. IEEE Trans Power Syst1999;14(4):1452–9.

[17]. TomonobuSenjyu," Hirohito Yamashiro, Katsumi Uezato, and Toshihisa Funabashi" A Unit Commitment Problem by using Genetic Algorithm Based on Unit Characteristic Classification", IEEE Trans. On Power System, vol.2, 2002.

[18].Kazarlis SA, Bakirtzis AG, Petridis V. A genetic algorithm solution to the unit commitment problem. IEEE Trans Power Syst 1996;11(1):83–92.

[19]. Kumar VS, Mohan MR. Solution to security constrained unit commitment problem using genetic algorithm.Int J Electr Power Energy Syst2010;32(2):117–25.

[20]. Sasaki H, Watanabe M, Yokoyama R. A solution method of unit commitment by artificial neural networks. IEEE Trans Power Syst 1992;7(3):974–81.

[21]. T. Logenthiran, Dipti Srinivasan," Particle Swarm Optimization for Unit Commitment Problem" IEEE Trans. On Power System, Vol.10, 2010.

[22]. T.O.Ting, M.V.C.Rao and C.K.Loo," A Novel approach for Unit Commitment Problem via an Effective Hybrid Particle Swarm Optimization," IEEE Trans. On Power System, vol.21, No.1, 2006.

[23].Sishaj PS, Padhy NP, Anand RS. An ant colony system approach for unit commitment problem. Int J Electr Power Energy Syst 2006;28(5):315–23.

[24]. EsmatRashedi, HosseinNezamabadi-pour, SaeidSaryazdi," GSA: A Gravitational Search Algorithm" Information Sciences, Vol. 179, 2009.

[25] Dr.Sudhir Sharma, Shivani Mehta,Nitish Chopra, "Economic Load Dispatch using Grey Wolf Optimization"Vol.5-Issue 4(April-2015),International Journal Of Engineering Research and Applications(IJERA),ISSN:2248-9622,www.ijera.com

[26] Dr.Sudhir Sharma, Shivani Mehta,Nitish Chopra, "Grey Wolf Optimization for solving Non-Convex Economic Load Dispatch"Vol.3-Issue 3(May-2015),International Journal Of Engineering Research (IJOER),ISSN:2321-7758,www.ijoer.in

[27] J. Kennedy and RC. Eberhart, "Particle swarm optimization," in Proceedings of IEEE international conference on neural networks, vol. 4, 1995, pp. 1942–1948.

[28] Sachin Kumar, Shivani Mehta, Dr. Y. S. Brar,"Solution of Economic Load Dispatch Problem using Gravitational Search Algorithm with Valve Point Loading" in Proceedings of International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 6, June – 2014

[29] Dr. Sudhir Sharma, Mrs. Shivani Mehta,Tamanna Verma," Weight Pattern Based Cuckoo Search for Unit Commitment Problem" in Proceedings of International Journal of Research in Advent Technology, Vol.3, No.5, May 2015 E-ISSN: 2321-9637.