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A GENETIC BASED STOCHASTIC APPROACH FOR SOLVING THERMAL UNIT COMMITMENT PROBLEM WITH INTELLIGENT ANNULAR GENETIC ALGORITHM

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Abstract:- *Unit commitment problem has several challenges which are under active research. To schedule most cost effective combinations of generating units, minimization of operational fuel cost and reduction in computational time for calculations are great challenges in this combinatorial optimization problem. The present analysis work has resolved the unit commitment downside chiefly specializing in minimum up/down time constraints; effectively handle by intelligent coding scheme. Previously annular crossover and intelligent scheme are applied independently in research work but in proposed GA, both are apply simultaneously in UCP. The proposed UC algorithm consists at two levels. First level searches the best on/off status schedule of the generation units by using GA search and the second level deals with economic dispatch problem. Load curve data has been taken for generating chromosomes to make initial population, annular crossover and flip bit mutation as genetic operators to produce next population. The proposed GA operators not only produce better solution but also prevent trapping in local optimum. The obtained results are better in terms of reduction of the search space, minimum cost solution and the convergence of algorithm when compare with other systems available in literature. The Performance of planned algorithmic program is checked on 2 completely different 10-unit 24-h test systems and for giant scale testing 20-unit 24-h, unit commitment check systems square measure taken into consideration.*

Key Words: *Unit commitment, Optimization Problem, Evolutionary programming, Intelligent Genetic Algorithm, Annular Crossover*

1. INTRODUCTION

In mathematics, optimization is the selection of the best solution from some set of available Alternatives. Basically, optimization problem consist of minimizing or maximizing an Objective function subject to some equality or inequality constraints. Unit commitment is also highly complicated, non-linear, combinatorial optimization problem. The engineers have to face the stimulating task of planning and successfully operating one of the most complex systems of engineering world. The proper planning and economic operation of power system always have serious matter in power industry because effective savings can be achieved over a specified time horizon. The effective operational planning of the power system includes the best utilization of available energy resources subject to several constraints to transfer electrical energy from generating stations e.g. IPPs or power plants to the users end without interruption of power supply at minimum cost with maximum safety of equipment. Unit commitment that conjointly known as generation Scheduling is incredibly vital stage in operational planning of installation that decides the on/off standing of generating units over a programing amount with minimum operating expense.t. Unit commitment problem also having different constraints, which must be satisfies for implementation in the real life system. If handle those constraints then we found best and feasible generation schedule to Minimize total production cost.

2. Mathematical Modeling of Unit Commitment Problem

The total production cost consist of the operating, start-up cost (cost of bringing units online), and shutdown cost. The operating cost of a generator consists of fuel cost and maintenance cost. The fuel cost of a generator depends upon the level of generation of that generator. When a feasible UC schedule is determined the next step is to find the optimum values of power for all committed units, which is known as Economic Dispatch (ED). Once the dispatch levels of all committed units are obtained, the fuel cost of each unit is calculated by using their fuel cost curves.

2.1 Objective Function

The main objective of UCP is to minimize the total operating cost over the scheduled period, which is sum of the fuel costs of the ON state units and the start-up costs of the OFF state units subject to the generating units and power system constraints. The complete objective function of UCP is expressed as;

$$\min TPC = \sum_{i=1}^{N}\sum_{t=1}^{T} \{(F_i(P_{i,t}) + STR_{i,t}(1 - U_{i,t-1})\}U_{i,t} + SDW_{i,t}U_{i,t-1}(1 - U_{i,t-1})\} \quad (1)$$

Here T is time horizon and N is expressed the number of units.

2.2 Fuel Cost

For the representation of fuel cost is most extensively used as quadratic approximation in the literature, which is primarily a convex shaped function. The fuel cost of a generating unit is mathematically written as: The total operating cost of *ith* unit at time t is determined by the quadratic function:

$$F_i(P_{i,t}) = a_i P_{i,t}^2 + b_i P_{i,t} + c_i (\frac{\$}{h}) \quad (2)$$

2.2 Start-up Cost

Startup Cost is calculated by:

$$STR\ Cost = \gamma_i + \varphi_i \left[1 - \exp\left(\frac{-x_{i,t}^{off}}{\tau_i}\right)\right] \quad (3)$$

Where γi *and* ψi are the hot start and cold start coefficients in ($) respectively used in Start-up cost equation and τi is the time constant of unit i. while is the de commits time of unit *i* also including initial state.

2.3 Constraints

There are two kinds of constraints in UCP.

- System Constraints
- Unit Constraints

2.3.1 System Constraints

Such constraints are associated with all generators in the system, therefore they are considered as coupling constraints or system constraints. System constraints consist of spinning reserve and power balance constraints. The detail of each constraint is given as follow:

2.3.2 Power Balance Constraint

Total power generated from all committed units at any time t must meet the load demand at that time. Mathematical formulation in given as:

$$\sum_{i=1}^{N} P_{i,t}\, U_{i,t} = D_t; \quad where\ t = 1,2,3,\ldots\ldots,T \quad (4)$$

2.3.3 Spinning Reserve Constraint

The spinning reserve is always necessary to maintain reliability of system. The sum of maximum power generated by all on-line units must be greater than or equal to sum of Load demand and spinning reserve requirement. The amount of the needful spinning reserve is usually determined by the maximum capacity of one or two largest generating units in the system or a given percentage of forecasted peak demand during the fixed time horizon

$$\sum_{i=1}^{N} U_{i,t} = D_t + R_t \quad where\ t = 1,2,3,\ \ldots,T \quad (5)$$

Rt is known minimum spinning reserve condition at time t.

2.3.4 Unit Constraints

These constraints are only associated with generator not with the system therefore, they are considered as non-coupling constraints. Each constraint is described as follows:

2.3.5 Unit Power Generation ranges

The power generated by each unit should be within its minimum and maximum bounds and mathematically formulated as follow:

$$P_{i,t}^{\min} \leq Pi,t \leq P_{i,t}^{\max} \qquad (6)$$

Where is the $P_{i,t}^{\max}$ known maximum power and is $P_{i,t}^{\min}$ known minimum power that unit *i* generated at any time interval t.

2.3.6 Minimum up Time and Minimum down Time

Minimum number of hours that a unit needs to be on-line once it has been turned on is called minimum up time. Similarly, minimum down time is the minimum number of hours that unit must be off-line once it has been turned off. Thus the status of a unit is highly dependent on the MUT and MDT constraints as shown:

First MUT defined as;

$$\text{Ui,t=1: } \sum_{j=ts}^{t-1} \text{(1-Ui,t)< Γi,up for i=1,2…N: and t=ts+1…..T} \qquad (7)$$

Where Γi.up is known as MUT of unit i.

And MDT defined as;

$$\text{Ui,t=0; } \sum_{j=td}^{t-1} \text{(1-Ui,t)< Γi,down for i=1,2………N: and t=td+1……..T} \qquad (8)$$

Where Γi,down is the known MDT of unit i.

2.4 Proposed Methodology for UCP

In 1859 Charles Darwin presented the theory of evolution which was based on the principal of natural selection and genetics i.e. “survival of the fittest” to reach certain significant tasks.

In GA, fixed-length string is used to represent individuals or chromosomes. Each site in the string is supposed to characterize a particular feature, and the value stored in that location represents how that feature have influence in the solution.

A GA starts with the generation of random initial population. Then the fitness of each individual is calculated by a fitness function. When the fitness is evaluated for all chromosomes, they are subjected to a process of selection in which best fit individuals have more chances of being selected as parents. Once the parents are selected, crossover and mutation operators are applied on them. The main reproduction operator used in GA is crossover, in which two individuals are used as parents and new chromosomes are formed by swapping or crossing genetic information between these strings. Mutation is another GA operator used for reproduction.

The GA steps used to solve the UCP in this research work along with their detail are given below;

2.4.1 Input Data for the UC Problem

The input data which is used while solving UCP by using GA can be of three types:

2.4.2 System Data

System data includes forecasted load demand in terms of real power over a schedule time horizon (T) along with the spinning reserve (SR) requirement. The SR is taken as some percentage of forecasted load demand or a fixed amount of real power.

2.4.3 Unit Data

Unit data for a UC problem contain the characteristic behavior of the cost curves of all the individual units. Unit data involve the hot and cold start-up details, start-up and shutdown costs, maximum and minimum power limits, minimum up and down times and initial status of all generating units.

2.4.4 GA Parameters

This kind of input data comprises of selection of all GA parameters setting such as crossover and mutation rates, string length, population size, termination criteria, fitness function and maximum number of generators etc.

2.4.5 Structure of Chromosomes

The on/off status of units are represented by binary variables i.e. '0' for OFF and '1' for ON. To represent the status of N units over a time horizon of T hours the dimension of chromosome will be T×N.

2.4.6 Coding Scheme of Unit Commitment

In the intelligent coding scheme a binary string X translates into another binary vector representation X' as shown in Fig.1 the main UCP constraints, MUT/MDT and the turbine/pump operating constraints are also combined into these representations as well.

$S_{(11)}$ $S_{(12)}$ $S_{(13)}$

1	01	0	11	1	00	.	.	.	.

$S_{(i1)}$ $S_{(i2)}$ $S_{(i3)}$

1	101	0	000	1	100	.	.	.	.

$S_{(N1)}$

1	0	0	0	0	1	1	.	.	.

Fig .1: The coding scheme, Matrix X'.

In Fig.1is shown that each row in the matrix express's the coded operating state for one unit during T-time step period. Each row of the coded states is divided into a number of segments called here substrings, expressed as, $(i1)$, $(i2)$, and $(i3)$. For the i^{th} row each substring represents one operating state, OFF (by leading bit 0) and ON (by leading bit 1), and how much time the OFF-state (or ON state) lasts. The length of substring n_i, for the ith unit is expressed as,

$$n_i = \begin{cases} 1+[\log_2(n_{i,\max})], \ldots\ldots\ldots\, for \ldots n_{i,\max} > 1 \\ 1, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\, otherwise \end{cases} \qquad (9)$$

In equation (9) $n_{i,\max}$ = max ($\Gamma_{i,up}$ $\Gamma_{i,down}$) for the ith unit. Which show that these two main constraints are included in the chromosomes binary string and they fulfill implicitly also. For example a unit i has $\Gamma_{i,up}$=2 hours and $\Gamma_{i,down}$=4hours, then $n_{i,max}$= 4 and n_i= 3. In this situation the sub string 1|01 represents that the unit is in ON state (due to the leading bit) and the up state continues up to 3 hours, i.e., 1 hour (shown by the binary value '01') plus 2-hours $\Gamma_{i,up}$. By analogy, the substring 0|11 imply that the unit is in OFF condition up to 7 hours, i.e., 3 hours (represents by '11') plus 4-hours $\Gamma_{i,down}$. In this way, even a random selection of entries of the matrix does not produce infeasible solutions with respect to MUT/MDT. For taking the $\Gamma_{i,up}$ =[2,3,2,1,1] and $\Gamma_{i,down}$=[4,3,3,1,1], n_i will be [3,2,2,1,1]. It is seen that for $n_{i,max}$= 1 , the sub string length decoded into 1. Thus each bit clearly specifies the unit state in each hour. The units having $n_{i,max}$> 1, it may be possible that the corresponding actual schedule taking the time horizon longer than 24 h, so in that case the scheduling period away from the 24th hour is ignored. Also the initial status of generating units can be involved in the same substring coding technique.

2.4.7 Economic Dispatch and Cost calculations

The lagrangian multiplier is a classical and effective technique used to solve the economic dispatch problem proposed by Wood & Wallenberg [1]. Its function is expressed as:

$$L = \sum_{i} F_i(P_{i,t}) + \lambda\phi \qquad (10)$$

Where λ is called undetermined lagrangian multiplier.

The required conditions for the minimum of the total production cost function are given as:

$$\frac{\partial L}{\partial P_i} = \frac{dF_i(P_{i,t})}{dP_i(t)} - \lambda = 0 \qquad (11)$$

For this required condition there must be the sum of all real power outputs must be equal to the load demand Dt. The inequalities of constraints must also be satisfied. For finding the best value of λ we use lambda-iteration method. By using this iterative method we change the value of λ in the systematic way:

Change the value of λ in the systematic way:

1- Firstly set the value of λ.

2- Then find the generating powers of each unit.

3-If the sum of generated powers of all units is lessthan the required demand then increase the λ and go to step 2.

4- If the sum of generated powers of all units is higher than the required demand then decrease the λ and go to step 2.

The advantage of λ iteration method is, for UCP its convergence towards global minimum is very fast and it automatically fulfills the power balance constraint. Power limit constraint is handled by clamping process and find lambda again of inviolate units for power balance constraints. So we can easily handle both economic dispatch constraints by using this method.

2.4.8 Selection

The selection operator guides towards the best solution and eliminates the less fit individuals by selecting the feasible and best fit chromosomes from the population. In the proposed work binary tournament selection [4] is applied for finding the optimum solution. This operator picks the two individuals from the population randomly at a time and produce temporary population, known mating pool. This selection procedure repeat itself is until the size of temporary population becomes equal to the original population.

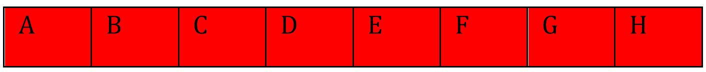
2.4.9 Crossover

In Genetic Algorithm, crossover is a major genetic operator which applied on two parents for the production of offspring generation. For the implementation of this operator two parent individuals are randomly selected from the temporary population, created after selection process and then genetic information is exchanged between them. The crossover probability (pc) is predefined for generating two new solutions.

2.4.9.1 Annular crossover:

In proposed work, for gets better convergence and solution new ring type crossover called Annular crossover has been used. The crossover operator is applied on two parents, selected from mating pool and then genetic information has been exchanged between them. Usually in GA, most common type of crossover, linear crossover is implemented on the chromosome which expressed in the form of binary string as shown in Fig. 2(a). While in proposed crossover chromosome is represented as a circular shape as shown in Fig. 2(b). First, for implementation of annular crossover on chromosome, define a number Cl which represent the starting point of crossover called locus point.

(a)String



(b)Ring

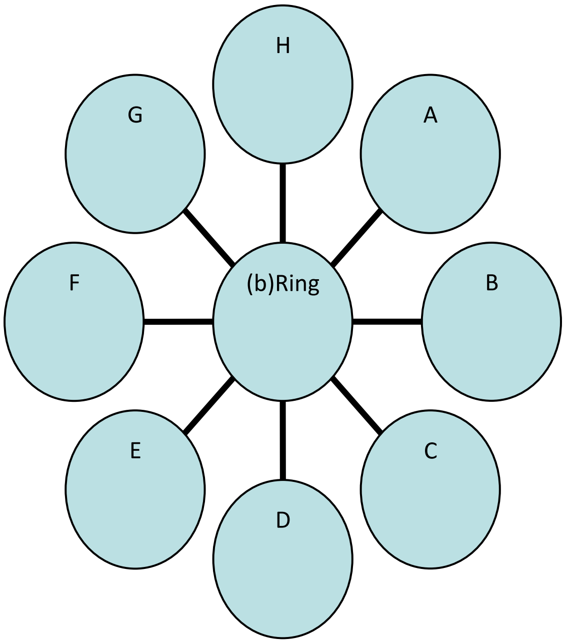


Fig. 2: Chromosome representation

The range of this number should be [1, L-1], Here L indicates the length of chromosome. In addition to, a number must be defined for establishing the semi-ring length Cs which is exchange during crossover. The length of semi-ring will be in the array [1,L/2]. The feasibility of solution also depends on effective exchanging of genetic information. So for this purpose the semi-ring length must be equal in both parent chromosomes.

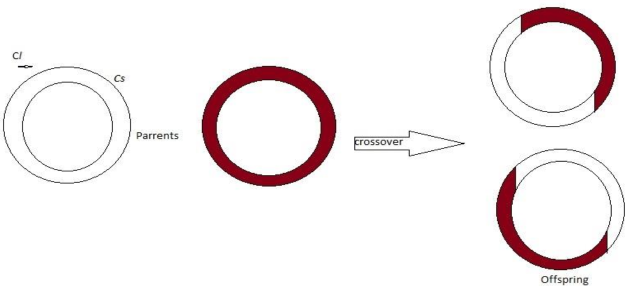


Fig. 3: Proposed Crossover

2.4.9.2 Annular crossover in UCP

For the UCP, annular crossover is described by using the following steps.

1. After the selection process, from each parent selected, a unit p and a unit q are randomly chosen.

2. By using the ring representation define the scheduling of chosen units as shown in fig. 4.

3. Select the crossover point Cl and the length of semi-ring Cs randomly. For this case L is defining for the 24 hours' time horizon. By taking an example where Cl is 22 for unit p and 18 for unit q as shown in fig. 5.

4. During crossover now exchange the genetic information in the semi ring and form new schedule for unit p and q which shown in fig. 6.

5. Convert backs this representation into linear representation of the offspring planning schedule of unit p and q.

6. End of crossover. The annular crossover operator terminates, when the individuals in the population has been completed.

2.4.9.3 Elitism

For increase the speed of convergence, elitism is used. In which the best individuals having best fitness value are maintaining their existence in the next generation and not to lose their useful genetic information. This proposed work uses a certain range of elitism from which the best chromosomes of the population are remain a part of new population.

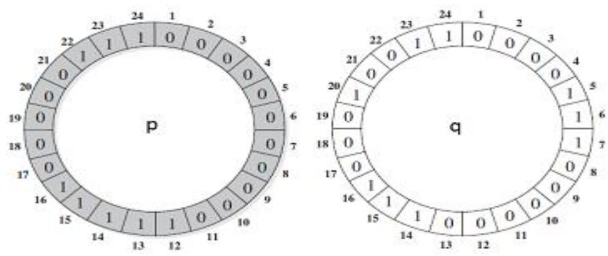


Fig. 4: Ring representation for unit p and q.

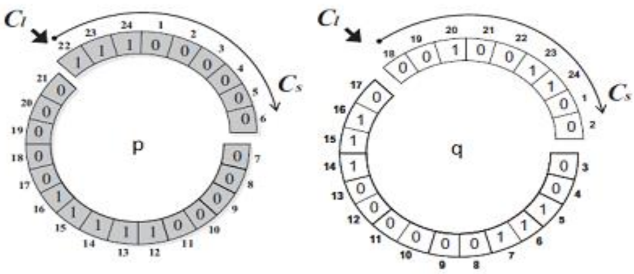


Fig. 5: Semi ring for the proposed Crossover

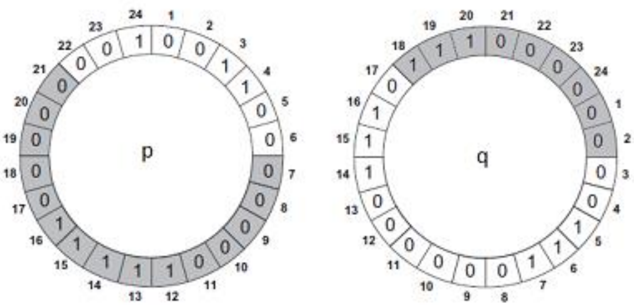


Fig. 6: Off-spring Schedule of unit p and q

2.4.9.4 Mutation

It is also a genetic operator which is used to maintain the genetic diversity from one generation to next generation. For the modification of genetic information in the chromosome, a mutation probability P_m is defined in GA based problems. This genetic operator just changes a bit which selected randomly from the matrix represents a chromosome from 0 to 1 or 1 to 0.

2.5 Main Features of proposed GA

1. This proposed algorithm not only handled small scale but also large scale system.

2. Most Constraints of UC are addressed such as:

   b) Spinning Reserve Requirement

   c) Minimum up Time (MUT) and Minimum down Time (MDT)

   d) Maximum & Minimum Power Limits of Units

e) Hot/Cold Start-up Cost

f) Must Run Units / Must off Units

g) Cold Start hours

h) Initial Status of Units

i) Shut down Cost

3. Methods for Economic Dispatch

- Lambda Iteration Method

4. Intelligent generation of initial population by focusing on load curve.

5. De-commitment of excessive units using intelligent mutation operator.

6. Constraints are satisfied without using penalty term.

7. Annular Crossover.

8. Bit flip mutation

4.5 Flow Chart of proposed GA

The Flow Chart of proposed GA showing all the steps of the proposed algorithm is shown in Figure 7.

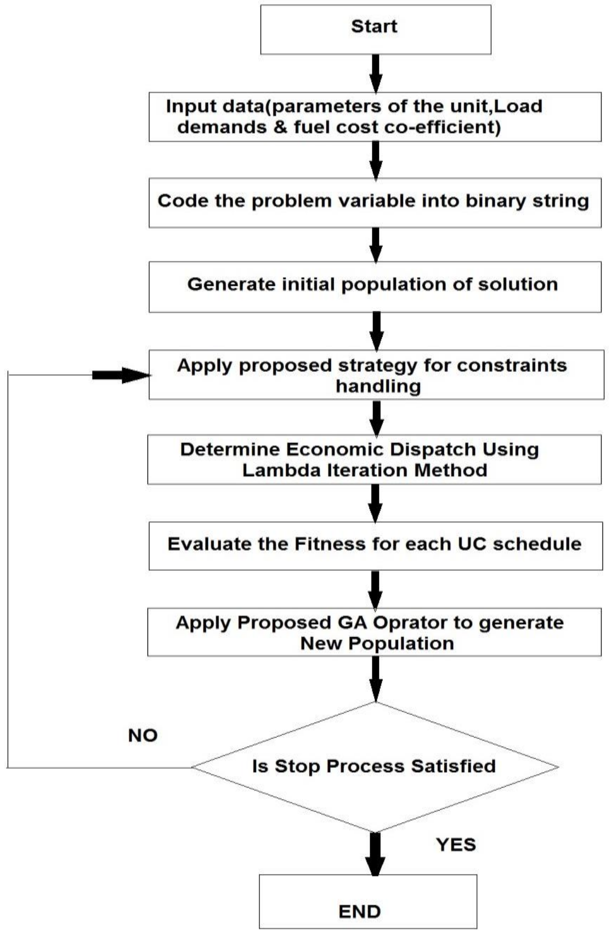


Figure 7: Flow chart of proposed Genetic Algorithm

3. RESULTS

3.1 Result from 10-unit test system (case 1):

For this small scale test system, the number of iterations and population size are taking 50 & 20. While mutation and crossover probabilities are set to 0.1 and 0.8 respectively.

Proposed GA is applied firstly on 10-unit test system for 24-hour time horizon, data obtained from [5]. Table 3.1 gives the optimum power generation schedule for this test system.

Comments:

Spinning reserve taken 10% of load. Obtained operating cost is $563930, which is lowest as compare to the other techniques mentioned in table 3.2. The cost comparison with other techniques is shown in fig 8.

3.2 Result from 10-unit test system (case 2):

The proposed algorithm also tested on second 10-unit system, which data obtained from [8]. Spinning reserve taken as 5% of load. The results obtained from that system are also improved. Also proposed coding scheme gives the advantage to produce feasible solution in each trial. 24-hour best UC schedule and total operating cost is given in table 3.3.

Comments:

The total operating cost for this test system is $ 560572, which is minimum cost as compare to other.

Techniques (ELR [9], EP [10], and IGA [11]) mentioned in table 3.4. The cost comparison with other techniques is shown in fig 9.

3.3 Result from 20-unit test system (Case 3):

As described earlier that 20 unit system data is obtained by using proper scaling on 10-unit test system data [5] and load demand multiplied by 2. From table 3.5, it is clearly shows that even for large scale UC problem; proposed algorithm shows feasible and minimum cost results.

Comments:

The minimum cost obtained by this large scale unit system is $ 1124260, which is lowest cost as compare to other techniques (IBPSO [2], BDE [7], GA [6]) mentioned in table 3.5. The best result is found from 30 independent trials. The cost comparison with other techniques is shown in fig10

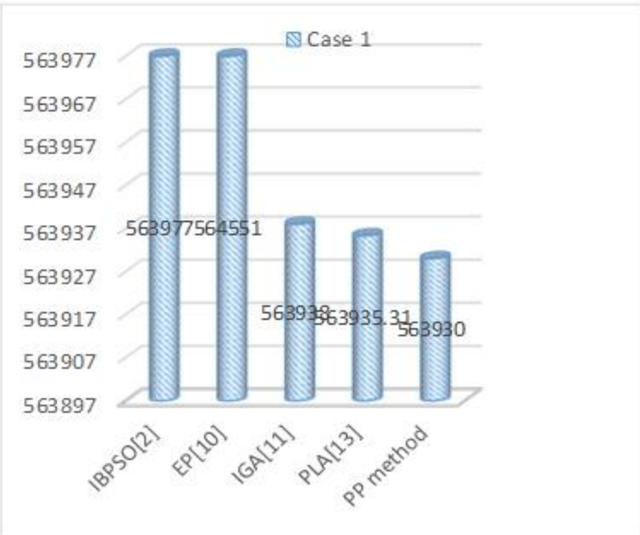


Fig 8: Cost Comparison of 10 Unit test system (Case 01)

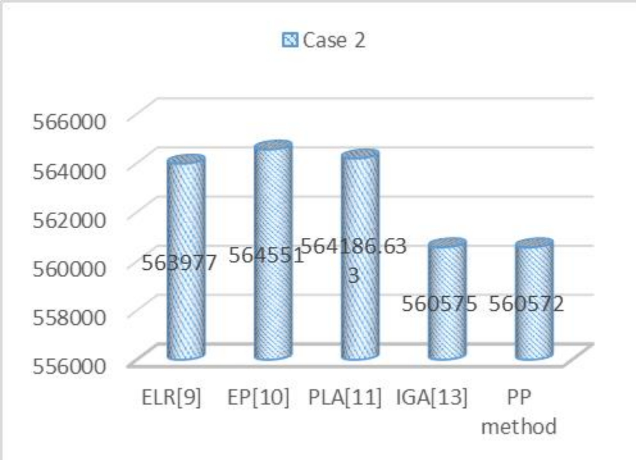


Fig 9: The cost comparison of 10 unit Test system (Case 02)

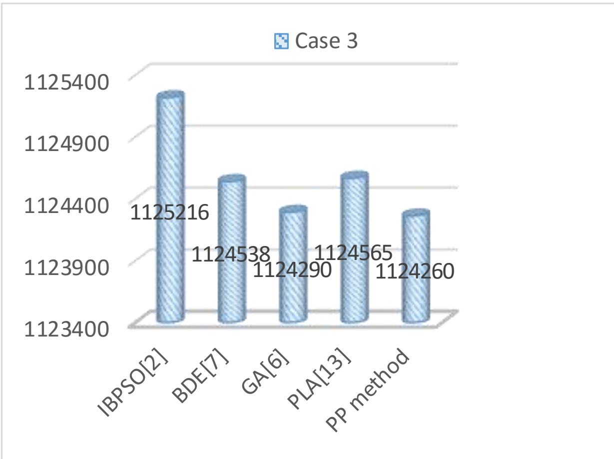


Fig 9: The cost comparison of 20 unit Test system (Case 03)

Table 03: Parameters for the 10 unit power system [5].

Unit i	$Pmax(MW)$	$Pmin(MW)$	$a_i(\$/h)$	$b_i(\$/MWh)$	$c_i(\$/MWh^2)$	$\Gamma_{i,up}(h)$	$\Gamma_{i,down}(h)$	$\gamma_i(\$)$	$\psi_i(\$)$	$\tau_i(h)$	$IS_i(h)$
1	455	150	0.00048	16.19	1000	8	8	4500	9000	5	8
2	455	150	0.00031	17.26	970	8	8	5000	10000	5	8
3	130	20	0.00200	16.60	700	5	5	550	1100	4	-5
4	130	20	0.00211	16.50	680	5	5	560	1120	4	-5
5	162	25	0.00398	19.70	450	6	6	900	1800	4	-6
6	80	20	0.00712	22.26	370	3	3	170	340	2	-3
7	85	25	0.00079	27.74	480	3	3	260	520	2	-3
8	55	10	0.00413	25.92	660	1	1	30	60	0	-1
9	55	10	0.00222	27.27	665	1	1	30	60	0	-1
10	55	10	0.00173	27.79	670	1	1	30	60	0	-1

Table 3.1: Best Generation Schedule for 10-unit system

Hour/Unit	Schedule	1	2	3	4	5	6	7	8	9	10	Startup Cost	Fuel Cost
1	1100000000	455	245	0	0	0	0	0	0	0	0	0	13683.1
2	1100000000	455	295	0	0	0	0	0	0	0	0	0	14554.5
3	1100100000	455	370	0	0	25	0	0	0	0	0	900	16809.4
4	1100100000	455	455	0	0	40	0	0	0	0	0	0	18597.6
5	1101100000	455	390	0	130	25	0	0	0	0	0	560	20020.0
6	1111100000	455	360	130	130	25	0	0	0	0	0	1100	22387.0
7	1111100000	455	410	130	130	25	0	0	0	0	0	0	23262.0
8	1111100000	455	455	130	130	30	0	0	0	0	0	0	24150.3
9	1111111000	455	455	130	130	85	20	25	0	0	0	860	27251.0
10	1111111100	455	455	130	130	162	33	25	10	0	0	60	30056.0
11	1111111110	455	455	130	130	162	73	25	10	10	0	60	31916.0
12	1111111111	455	455	130	130	162	80	25	43	10	10	60	33889.1
13	1111111100	455	455	130	130	162	33	25	10	0	0	0	30057.5
14	1111111000	455	455	130	130	85	20	25	0	0	0	0	27251.0
15	1111100000	455	455	130	130	30	0	0	0	0	0	0	24150.3
16	1111100000	455	310	130	130	25	0	0	0	0	0	0	21513.6
17	1111100000	455	260	130	130	25	0	0	0	0	0	0	20641.8
18	1111100000	455	360	130	130	25	0	0	0	0	0	0	22387.0
19	1111100000	455	455	130	130	30	0	0	0	0	0	0	24150.3
20	1111111100	455	455	130	130	162	33	25	10	0	0	490	30052.5
21	1111111000	455	455	130	130	85	20	25	0	0	0	0	27251.0
22	1100111000	455	455	0	0	145	20	25	0	0	0	0	22734.5
23	1100010000	455	425	0	0	0	20	0	0	0	0	0	17645.4
24	1100000000	455	345	0	0	0	0	0	0	0	0	0	15425.4

TOTAL PRODUCTION COST: 559840+4090=$ 563930

Table 3.2: Comparison of total production cost of 10 units case 1

Number of units	Total production cost ($)				
	IBPSO[2]	EP[10]	IGA[11]	PLA[13]	PROPOSED
10	563977	564551	563938	563935.31	563930

Table 3.3: Best UC schedule for 10-unit 24-hour

Hour/Unit	Schedule	1	2	3	4	5	6	7	8	9	10	Startup Cost	Fuel Cost
1	1100000000	455	245	0	0	0	0	0	0	0	0	0	16667.1
2	1100000000	455	295	0	0	0	0	0	0	0	0	0	16839.6
3	1100100000	455	370	0	0	25	0	0	0	0	0	900	16809.4
4	1100100000	455	455	0	0	40	0	0	0	0	0	0	18597.6
5	1101100000	455	390	0	100	25	0	0	0	0	0	560	19608.5
6	1111100000	455	360	100	130	25	0	0	0	0	0	1100	21860.3
7	1111100000	455	410	130	130	25	0	0	0	0	0	0	23262.0
8	1111100000	455	455	130	130	30	0	0	0	0	0	0	24150.3
9	1111111000	455	455	130	130	85	20	25	0	0	0	860	26588.9
10	1111111100	455	455	130	130	162	33	25	10	0	0	60	29269.9
11	1111111110	455	455	130	130	162	73	25	10	10	0	60	31117.4
12	1111111111	455	455	130	130	162	80	56.6	10	10	11.4	60	33014.3
13	1111111100	455	455	130	130	162	20	25	23	0	0	0	29269.9
14	1111111000	455	455	130	130	85	20	25	0	0	0	0	26588.9
15	1111100000	455	455	130	130	30	0	0	0	0	0	0	24150.3
16	1111100000	455	310	130	130	25	0	0	0	0	0	0	20895.9
17	1111100000	455	260	130	130	25	0	0	0	0	0	0	20020.0
18	1111100000	455	360	130	130	25	0	0	0	0	0	0	21860.3
19	1111100000	455	455	130	130	30	0	0	0	0	0	0	24150.3
20	1111111100	455	455	130	130	130	60	25	15	0	0	490	29269.9
21	1111111000	455	455	130	130	85	20	25	0	0	0	0	26588.9
22	1100111000	455	455	0	0	145	20	25	0	0	0	0	21860.3
23	1100110000	455	425	0	0	25	0	0	0	0	0	0	17684.7
24	1100000000	455	345	0	0	0	0	0	0	0	0	0	15427.4

Total Production cost: Fuel Cost (555552) + Startup cost (5020) = $ 560572.0

Table 3.4: Comparison of total production cost of 10 units case 2

Number of units	**Total production cost ($)**				
	ELR[9]	EP[10]	PLA[13]	IGA[11]	PROPOSED
10	563977	564551	564186.635	560575	560572

Table 5.5: Comparison of total production cost of 20 units case 3

Number of units	Total production cost ($)				
	IBPSO[2]	BDE[7]	GA[6]	PLA[13]	PROPOSED
20	1125216	1124538	1124290	1124565	1124260

4. CONCLUSION

Unit commitment is a non-linear, mixed integer, highly complex, combinatorial optimization problem. It is a critical step in power system planning after short term load forecasting phase. There are many techniques in the literature are discussed earlier and divided into three major categories, i.e. classical, meta-heuristic and hybridized techniques. But each of them having some advantages and disadvantages and requires some improvements in their algorithms to handle this complex optimization problem. In this paper, by using new proposed GA, the most difficult constraints of generation scheduling MUT/MDT is easily handled. For economic dispatch problem, lambda iteration method is used, which easily handled, power balance and generation limits constraints. By using direct coding scheme of GA, after several generations, it fails to yield feasible results for large scale systems. The results obtained from different test systems either small or large-scale shows the effectiveness of proposed algorithm. And it show minimum operating cost as compare to other reported methods. As a result it can easily say that proposed GA is an effective tool to handle the UC problem without any constraint violation. The proposed GA has a high probability to find the global solution, especially in convex formulations.

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