Paper accepted for presentation at 2009 IEEE Bucharest Power Tech Conference, June 28th - July 2nd, Bucharest, Romania

A New Meta-heuristic Method for Profit-Based Unit Commitment under Competitive Environment

H. Mori, *Member, IEEE*, and K. Okawa, *Student Member, IEEE*

***Abstract*-This paper proposes a new hybrid meta-heuristic method for profit-based unit commitment (PBUC) that considers units with nonlinear cost function. The proposed method aims at global optimization to carry out profit maximization under competitive environment. The objective of the traditional UC is to minimize operation-cost while satisfying the constraints. However, power system operation needs reformulate tasks that reflect the changes due to the deregulated power systems. As a result, GENCO is interested to determine generation scheduling from a standpoint of maximizing profit under competitive environment. The problem may be formulated as PBUC that corresponds to a nonlinear mixed-integer problem. It is hard to solve due to the complexity. In this paper, a new hybrid meta-heuristic method is proposed to solve PBUC. It makes use of improved TS-EPSO techniques that evaluates solutions with two layers of meta-heuristics. Layer 1 determines the on-off state of generators with Tabu Search (TS) while Layer 2 evaluates output of generators with the evolutionary particle swarm optimization (EPSO). TS is very useful for solving a combinatorial optimization problem efficiently. EPSO has better performance in dealing with an optimization problem with continuous variables. In this paper, TS-EPSO is improved to give more accurate solutions with less CPU time. The proposed method determines a new load curve for maximizing the profit finally. The effectiveness of the proposed method is successfully applied to a sample system.**

***Index Terms*—unit commitment, profit maximization, hybrid meta-heuristics, mixed-integer problem, TS, EPSO, global optimization**

I. INTRODUCTION

THIS paper proposes a new profit-based unit commitment (PBUC) that considers units with nonlinear cost function and an improved hybrid meta-heuristic method. The proposed method consists of two meta-heuristic techniques to solve unit commitment (UC) for maximizing profit under competitive environment. The traditional UC is one of difficult scheduling problems for minimizing operation cost of units while satisfying the constraints on generators and system characteristics [1]. However, in recent years, power systems become deregulated and competitive so that the power system operation requires the problem reformulation that reflects the changes under new environment. The deregulated power systems make new GENCOs supply electric power to players. That brings about the advantage and disadvantage of GENCOs. The advantage is that they do not necessarily have to meet load demand for tight load demand since there are a number GENCOs. On the other hand, the disadvantage is that the revenue decrease through not supplying electric power. As a result, GENCOs are interested in determining generation scheduling from a standpoint of maximizing a profit under competitive environment. The problem may be formulated as profit-based UC (PBUC). It plays a key role to deal with maximizing profits and minimizing risks. GENCOs do not have to meet the constraints on demand and reserves [8]. In the new problem formulation, the electricity price become more important as a parameter. PBUC is very useful for evaluating optimal bidding strategies [9]. In addition, the fuel cost function is approximated by the quadratic function in the conventional methods. The indifferentiable nonlinear fuel cost function of large steam turbine generators is not considered for PBUC. As a result, it is necessary to hedge risk through realizing the practical approach [5], [7].

The problem formulation of unit commitment may be expressed as a nonlinear mixed integer problem. It may be divided into two phases; Phase one is a discrete optimization problem for determining optimal on-off state of generators while the other is a continuous optimization problem for evaluating optimal output of generators that corresponds to economic load dispatching (ELD). The conventional methods used mathematical programming such as nonlinear programming, dynamic programming, integer programming as well as heuristics. It is difficult to solve the real-world problems due to the deterioration of computational efficiency and/or solution accuracy.

In recent years, meta-heuristics is very attractive in a sense that it gives better solutions within given time [1]. It means an optimization method that repeatedly makes use of simple rules and heuristics to evaluate highly approximate solutions of a global minimum efficiently. Specifically, it has a couple of advantages. One is to obtain better solutions through a strategy for escaping from a local solution. The other is to handle indifferentiable cost functions and constraints.

This paper proposes a new hybrid meta-heuristic method for the PBUC problem. The proposed method evaluates a highly approximate global optimal solution to realize that GENCO maximizes a profit under competitive environment. Hybrid meta-heuristics means an optimization method that combines a meta-heuristics method with others to outperform the conventional meta-heuristics. Recent research results have

Manuscript received March 10, 2009. This work was supported in part by the Meiji University High Research Center.

H. Mori and K. Okawa are with Department of Electronics and Bioinformatics, Meiji University, Kawasaki 214-857, Japan (e-mail: hmori@isc.meiji.ac.jp).

978-1-4244-2235-7/09/$25.00 ©2009 IEEE

shown that hybrid meta-heuristics gives better results than simple meta-heuristics [1], [6]. The proposed hybrid meta-heuristics method consists of TS (Tabu Search) and EPSO (Evolutionally Particle Swarm Optimization). In addition, TS and EPSO are improved to enhance solution accuracy and computational efficiency. The improved TS at Layer 1 determines the optimal on-off state while the improved EPSO at Layer 2 evaluates the optimal output of each unit. The proposed method handles any type of generators by EPSO. In the proposed method, PBUC is solved from the final solution of UC. The proposed method determines a new load curve for maximizing the profit. This paper proposes flexible PBUC by considering nonlinear unit. The effectiveness of the proposed method is demonstrated in a sample system.

II. Problem Formulation

This section describes the problem formulation of PBUC under competitive environment. The objective is to maximize profit while satisfying the constraints on the demand, unit output and minimum up or down time of unit, reserves, and so on. The PBUC problem may be represented as a constrained maximization problem.

Objective function:

$$PF = RV - TC \rightarrow \max \tag{1}$$

$$RV = \sum_{i=1}^{n}\sum_{j=1}^{t} ST_{i,j} \cdot P_{i,j} \cdot SP_j \tag{2}$$

$$TC = \sum_{i=1}^{n}\sum_{j=1}^{t} \left\{ \begin{matrix} f_i(P_{i,j}) + SC_i \cdot ST_{i,j}(ST_{i,j} - ST_{i,j-1}) \\ + DC_i \cdot ST_{i,j-1}(ST_{i,j-1} - ST_{i,j}) \end{matrix} \right\} \tag{3}$$

Subject to

$$\sum_{i=1}^{n} ST_{i,j} P_{i,j} \le D_j \tag{4}$$

$$\sum_{i=1}^{n} ST_{i,j} R_{i,j} \le SR_j \tag{5}$$

$$ST_{i,j} P_{\min,j} \le P_{i,j} \le ST_{i,j} P_{\max,j} \tag{6}$$

$$ST_{i,j-1}(ST_{i,j-1} - ST_{i,j})\left(\sum_{m=1}^{MU_i} ST_{i,j-m} - MU_i\right) = 0 \tag{7}$$

$$ST_{i,j}(ST_{i,j} - ST_{i,j-1})\left(\sum_{m=1}^{MD_i} ST_{i,j-m}\right) = 0 \tag{8}$$

$$a_i P_{i,j}^2 + bP_{i,j} + c_i \tag{9}$$

$$a_i P_{i,j}^2 + b_i P_{i,j} + c_i + \left| e_i \times \sin\left(f_i \times (P_{\min,i} - P_{i,j})\right)\right| \tag{10}$$

$$SC_i = \begin{cases} h - \text{cost}_i & if \quad X_i^{off} \le MD_i + cold\_start\_hrs_i \\ c - \text{cost}_i & otherwise \end{cases} \tag{11}$$

where,

PF : profit of GENCO
RV : revenue of GENCO
TC : total cost of GENCO
n : no. of units
t : time duration
$P_{i,j}$: power generation of unit i for duration j
$ST_{i,j}$: on-off state of unit i for duration j
SC_i : start-up cost of unit i
DC_i : stop-down cost of unit i
D_j : forecasted total loads for duration j
$P_{min,i}$: minimum generation of unit i
$P_{max,i}$:maximum generation of unit i
MU_i : minimum up time of unit i
MD_i : minimum down time of unit i
SR_j : forecasted reserve for duration j
$R_{i,j}$: reserve generation of unit i for duration j
a_i, b_i, c_i, e_i, f_i : coefficients of unit i
$h\text{-}cost_i$: hot_start_cost of unit i
$c\text{-}cost_i$: cold_start_cost of unit i
X_i^{off} : continuous down time of unit i

The left side of (1) that expresses the profit is maximized. Equation (2) of the generation cost consists of fuel costs, start-up costs and stop-down costs is deducted from equation (3) of the revenue of GENCO. Equations (3) consists of spot price and generations. Equations (4) and (5) are different from the traditional UC in a way that if more profit is generated, GENCOs may select demand and reserves less than the forecasted ones. Equation (6) defines the limitation of unit output from the lower to the upper bound. Equations (7) and (8) express the minimum period that each unit continues on-state and off-state, respectively. Equation (9) denotes the fuel cost function of usual generators. Equation (10) is the fuel cost function of large steam turbine generators. This type unit opens turbine valves to gain further generations. For valve point loading, the absolute value of the sine wave is added to (9) [7]. As it is indifferentiable, it is hard to solve with the gradient method. Equation (11) is the characteristics of the start-up cost. The start-up cost increases corresponding with the continuous down time.

III. Ts and Epso

As fundamental meta-heuristics, this section describes TS and EPSO that deal with discrete and continuous variable optimization, respectively. TS is useful for solving a combinatorial optimization problem efficiently [2]. Glover developed TS that added the adaptive memory function called tabu list to the hill climbing method (HCM). It creates and searches neighborhood solutions that are based on an initial solution, and moves to the best solution of the neighborhood. By repeating this procedure, it evaluates the best solution. As a result, HCM is faced with a problem to fall into a local solution easily. Therefore, TS saves the movement history of the solution in the tabu list so that it enables to escape from a local solution by prohibiting a certain movement. TS gives the highly precise approximation solutions close to the global solution.

EPSO proposed by Miranda [4] is an extension of PSO developed by Kennedy and Eberhart [3]. Although PSO looks useful, it has a drawback that the adjustment of the parameters is very hard in real-world problems. EPSO combines PSO with the evolutionary strategy to solve an optimal problem effectively. PSO is one of the swarm intelligence techniques that simulates the behavior of the swarm of bird or fish and optimizes the function with multi-point search called agents. PSO discovers bait, *i.e.*, an optimal solution while sharing information in a swarm. Also, it is good at solving a problem with continuous variables. The agent memorizes the best solution of the self and the whole swarm in each search history, and determines the next direction to move using them stochastically. However, PSO need set the parameters that are the most suitable for a given problem to escape from a local solution. It is quite hard to tune up them actually. To improve the performance of PSO, EPSO combines the PSO method with the evolutionary strategy of the replication, mutation and reproduction, evaluation and selection. In other wards, EPSO means a technique that takes in the information exchange of the search in PSO and concepts such as natural selection or the mutation in the evolutionary strategy. By carrying out this strategy, high quality individuals are saved. It is possible to determine the good direction of the next generation through the self-adjustment of the parameters. EPSO also searches various from one agent. In addition, it may search the solution candidates in the neighborhood of the best solution. EPSO discovers better approximation solutions of the global solution by escaping from a local minimum.

IV. Proposed Method

This section proposes an efficient hybrid meta-heuristic method that consists of variable neighborhood TS (VTS) and parallel EPSO with island model (PEPSO). The hybrid meta-heuristics for the PBUC consists of two layers in which Layer 1 optimizes on-off states of unit by TS and Layer 2 evaluates the optimal output of unit by EPSO. The conventional TS has a drawback that search space is small in sense that it gets stuck in ta local solution. Therefore, TS is improved by applying variable neighborhood search to TS. The improved TS is referred to as Variable neighborhood Tabu Search(VTS). EPSO has shown the effectiveness in various complicated problems. However, EPSO has room for improving the solution quality and computational efficiency. Therefore, EPSO is improved by employing an island model like parallel GA.

A. Two-Layered Meta-heuristics

Two layered meta-heuristics is effective for solving a nonlinear mixed integer problem. It consists of two layers in which Layer 1 determines the on-off state of generators with TS while Layer 2 evaluates output of generators with EPSO (see Fig. 1). First, TS makes neighborhood solutions around an initial solution at Layer 1. EPSO at Layer 2 evaluates ELD each time neighborhood solutions are created at Layer1. By repeating the above process, the state and output of units are evaluated through the decomposition of optimization at Layers 1 and 2..

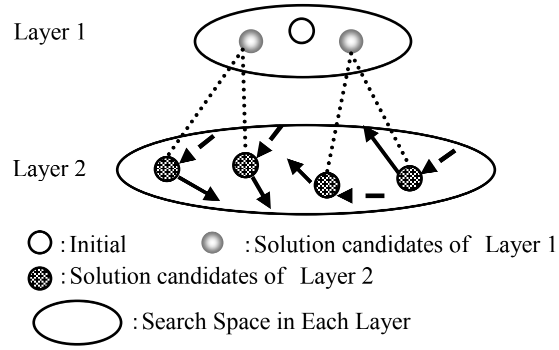

Fig. 1. Concept of two layered meta-heuristics

B. Variable Neighborhood TS (VTS)

VTS is proposed to find out better solutions at Layer 1 effectively. VTS is a method that applies variable local search(VLS) to TS. VLS proposed by Hansen aims at obtaining better solutions[12]. VLS has advantage that it maintains the diversity of solutions. As a result, it is expected that VLS escapes from a local solution. By combining TS with this strategy, TS realizes to obtain better solutions from local minimum. In this paper, the conventional TS is carried out by employing neighborhood of Hamming distance 1. If the best solution of search memory of TS is updated, VTS is run with the neighborhood search of Hamming distance 2 to keep the solution diversity. Therefore VTS has better performance than the conventional TS.

C. Parallel EPSO with Island Model (PEPSO)

PEPSO is proposed to improve the performance of EPSO in terms of solution quality and computational efficiency. Although EPSO has many advantages and shows the effectiveness in various problems, EPSO has a drawback that it needs wider search space in complicated problems to enhace the performance. Therefore, this paper focus on the parallel and distribute algorithm like the island model in GA. Fig. 2 shows the concept of parallel EPSO with island model. First more two islands are created to exchange subpopulation with other islands after EPSO is carried out in each island independently. The difference between the conventional EPSO and PEPSO is whether the migration operator is used or not. The evolved agents in each island are selected to migrate with other islands if the number of iterations is satisfied as the migration interval. The rate of migration agent is called migration rate. There exist several versions as to how to migrate. Normally, the ling-shaped topology is created like Fig. 2. As a result, the evolution of islands is accelerated by bringing cross cultural information to other islands. If evolution of islands stops, the evolution of islands becomes reactivated by migration. In that sense, the migration operator plays an important role to improve the solutions.

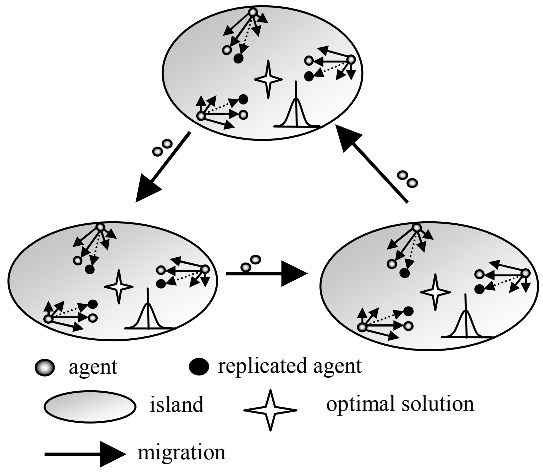

Fig.2 Concept of Parallel EPSO with Island Model

Table.1 Parameters of each method

Methods	Parameters	
VTS	Tabu length	80
	No. of iterations	100
	Variable rate	0.1
PEPSO	No. of agents	60
	Replication rate	2
	Initial w_1, w_2, w_3	0.01, 0.01, 1
	τ_1, τ_2	0.02, 0.01
	No. of iterations	300
	No. of islands	3
	Migration rate	0.1
	Migration interval	50

keeping the diversity of islands. The parameters of migration rate and migration interval affect the solution quality. If each island corresponds to one CPU processor, PEPSO has high performance through the distributed algorithm. The located vectors are associated with objective parameter for EPSO. In this paper, the located vectors are given as follows:

$$S_i\left[P_{1,j}, P_{2,j}, \cdots, P_{i,j}, \cdots, P_{n,j}\right] \quad (12)$$

where, S_i: located vectors set of agent i

V. Simulation

A. Simulation Conditions

i) The proposed method is tested in the generators, demands and spot prices data of 10-unit system with 24-periods[8],[10]. The state of units is expressed in 240 bits by binary code. The problem size of combinations results in 1.77×10^{72}. The problem to be solved is one of more complicated problems.

ii) The constraint on the reserves is assumed to be 8% of the total load during the interval. In addition, the constraints of (6) are considered in EPSO. Also, the constraints of (4), (5), (7), and (8) are taken into account in TS by adding the penalty function to the cost function. ELD is carried out for solution candidates that meet all the constraints on (4), (5), (7), and (8) for reducing the calculation time.

iii) The proposed method is compared with the conventional method of [10] . It does not consider nonlinear units and traditional UC in terms of the solution accuracy and CPU time. The first and second unit follows (10) to provide largest maximum output. The rest follows (9). In the proposed method, PBUC is solved from the final solution of UC The parameters of each method are determined through *a prior* simulation results and are given in Table 1. For convenience, the followings methods are defined :

Method A : Muller Method*
Method B : VTS-PEPSO* (Proposed Method)
Method C : VTS-PEPSO (Proposed Method)
Note) * mark shows that nonlinear units are not considered

Table.2 Comparison of each method for profit

Methods	Profit [$]	CPU Time [s]
Method A with UC*	75093	-
Method A with PBUC*	103296	-
Method B with UC*	90455	-
Method B with PBUC*	105873.8	131.6
Method C with UC	87956.7	-
Method C with PBUC	103374.4	144.2

Note) * mark shows that the nonlinear units are not considered.

Table.3 Generation plan of conventionalUC for Method C

Period	Generations of units [MW]									
	1	2	3	4	5	6	7	8	9	10
1	455	245	0	0	0	0	0	0	0	0
2	455	295	0	0	0	0	0	0	0	0
3	455	370	0	0	25	0	0	0	0	0
4	455	455	0	0	40	0	0	0	0	0
5	455	390	0	130	25	0	0	0	0	0
6	455	455	0	130	60	0	0	0	0	0
7	455	455	85	130	25	0	0	0	0	0
8	455	455	130	130	30	0	0	0	0	0
9	455	455	130	130	110	20	0	0	0	0
10	455	455	130	130	162	33	25	10	0	0
11	455	455	130	130	162	73	25	10	10	0
12	455	455	130	130	162	80	25	10	43	10
13	455	455	130	130	162	33	25	10	0	0
14	455	455	130	130	110	20	0	0	0	0
15	455	455	130	130	30	0	0	0	0	0
16	455	310	130	130	25	0	0	0	0	0
17	455	260	130	130	25	0	0	0	0	0
18	455	360	130	130	25	0	0	0	0	0
19	455	455	130	130	30	0	0	10	10	0
20	455	455	130	130	162	48	0	0	0	0
21	455	455	130	130	110	20	0	0	0	0
22	455	455	0	130	40	20	0	0	0	0
23	455	425	0	0	0	20	0	0	0	0
24	455	345	0	0	0	0	0	0	0	0

Table.4 Generation plan of PBUC for Method C

Period	Generations of units [MW]									
	1	2	3	4	5	6	7	8	9	10
1	455	245	0	0	0	0	0	0	0	0
2	455	295	0	0	0	0	0	0	0	0
3	455	395	0	0	0	0	0	0	0	0
4	455	455	0	0	0	0	0	0	0	0
5	455	455	0	0	90	0	0	0	0	0
6	455	455	0	0	162	0	0	0	0	0
7	455	455	0	0	162	0	0	0	0	0
8	455	455	0	0	162	0	0	0	0	0
9	455	455	0	130	162	0	0	0	0	0
10	455	455	130	130	162	0	0	0	0	0
11	455	455	130	130	162	80	0	0	0	0
12	455	455	130	130	162	80	0	0	0	0
13	455	455	130	130	162	68	0	0	0	0
14	455	455	130	130	130	0	0	0	0	0
15	455	455	130	130	0	0	0	0	0	0
16	455	335	130	130	0	0	0	0	0	0
17	455	285	130	130	0	0	0	0	0	0
18	455	385	130	130	0	0	0	0	0	0
19	455	455	130	130	0	0	0	0	0	0
20	455	455	130	130	0	0	0	0	0	0
21	455	455	130	130	0	0	0	0	0	0
22	455	455	0	130	0	0	0	0	0	0
23	455	425	0	0	0	0	0	0	0	0
24	455	345	0	0	0	0	0	0	0	0

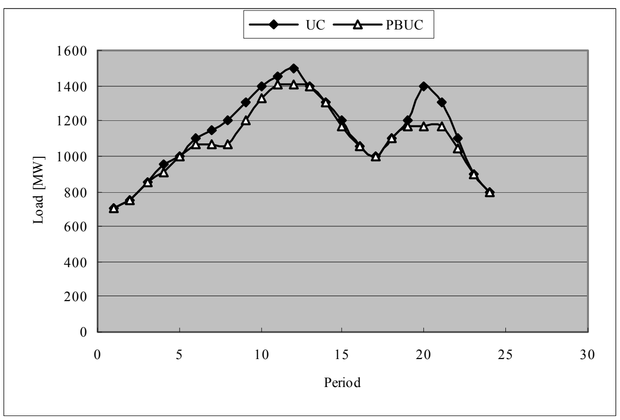

Fig.3 Load Curve of profit maximization for Method C

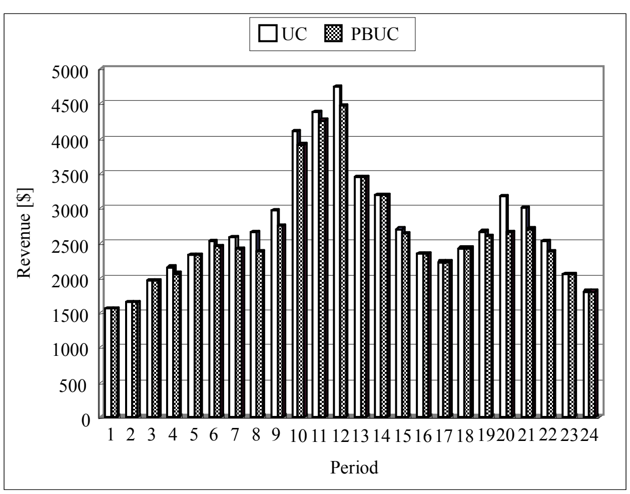

Fig.4 Comparison of revenue with each period for Method C

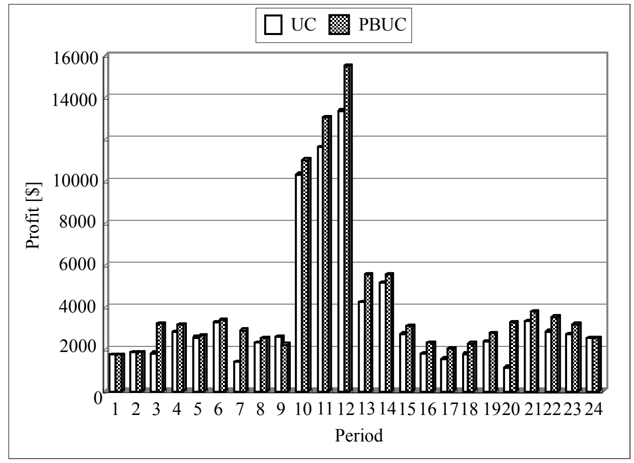

Fig.5 Comparison of profit with each period for Method C

B. Simulation Results

Table 2 gives the comparison of each method for the profit and CPU time for UC and PBUC. It can be seen that the proposed method of Method B is better than Method A in terms of the profit for both UC and PBUC in case where the nonlinear units are not considered. In UC, the proposed method solves the minimum cost planning efficiently so that it obtains more profit than Method A. In addition, the proposed method makes use of the final solution of UC as the initial solution of PBUC. The proposed method succeeded in reducing about 2.5% for Method A. Next, in case where the nonlinear units are considered, the profit of Method C is worse than Method B. The difference between two methods is 2499.4 [$]. This implies that nonlinear units are increased for the future or approximate units are used every day, so that serious damage may be received for accumulations of that difference of error calculation for the future. To avoid risk for the future, it is important that PBUC planning with nonlinear units is proposed. Method C succeeded in increasing about 17.5% of the profits for traditional UC. Although Method C is worse than Method B in terms of CPU time, the difference of 12.6 [s] is acceptable. Tables 3 and 4 show generation plans of UC and PBUC, respectively. It can be seen that the generation plan of UC is different from one of PBUC obviously. Fig. 3 shows a load carve where the profits of maximization are obtained finally. The load curve obtained in PBUC has indicated that PBUC decreases all the generations if power demands of the first load cuve in UC is high, t more profits are obtained. Fig. 4 shows difference of revenues in UC and PBUC of every period, respectively. Fig. 5 shows the difference of profits between in UC and PBUC for every period. Fig. 4 indicates that UC obtains more revenue than PBUC for most periods. This reason is why PBUC decreases generations of power. However, PBUC obtains more profits than UC in Fig. 5 so that the disadvantage of PBUC with regard to revenues is acceptable. In addition, the load curvee is obtained for the profit maximization It is expected that the deregulation of power systems becomes more activated by solving PBUC. Therefore, the simulation results have indicated that the proposed method gave a better solution effectively.

VI. Conclusion

In this paper, a new hybrid meta-heuristic method has been proposed to handle the profit-based unit commitment problem under competitive environment. It is based on an improved hybrid meta-heuristic of VTS and PEPSO. The results obtained may be summarized as follows:

i) This paper proposed an efficient hybrid meta-heuristic method that divides the nonlinear mixed-integer problem of the PBUC into two layers. The use of EPSO has advantage that it deals with indifferentiable cost functions of large steam turbine generators. VTS finds out better solutions by applying variable neighborhood search to TS. PEPSO with island model provided better solutions with less computational time.

ii) The proposed method was applied to the 10-units systems in which some units have the indifferentiable fuel cost function. The proposed method succeeded in increasing about 17.5% of the profits for traditional UC. To avoid risk in the future, it is important that PBUC planning with nonlinear units is proposed. It is expected that the proposed method is useful for determining a new load carve for maximizing the profit. The proposed method allows GENCOs to make a profit as the manage strategy effectively.

VII. References

[1] H. Mori and O. Matsuzaki, "Embedding the Priority List into Tabu Search for Unit Commitment," IEEE Power Engineering Society Winter Meeting, 2001, Vol. 3, pp. 1067-1072, Jan. / Feb. 2001

[2] F. Glover, " Tabu Search, Part I,"ORSAJ. Computing, Vol. 1, No. 3, pp. 190-206 (1989-summer)

[3] J. Kennedy and R. Eberhart, "Particle Swarm Optimization," Proc. of IEEE International Conference on Neural Networks, Vol. 4, pp. 1942-1948, Nov. / Dec. 1995

[4] V. Miranda and N. Fonseca, "EPSO-Best-of-Two-words Meta-Heuristic Applied to Power System Problem," Proc. of the IEEE Congress on Evolutionary Computation, Vol. 2, pp. 1080-1085, Jun. 2002

[5] J. Wood and B. F. Woolenberg, " Power Generation Operation & Control, " John Wiley & Sons, New York, USA 1989

[6] H. Mori and Y. Maeda : "Application of Two-Layered Tabu Search to Optimal Allocation of UPFC for Maximizing Transmission Cap Capability, " IEEE ISCAS. 2006, pp.1609-1702, May 2006

[7] L. dos. S. Coelho and V. C. Mariani: "Combining of Chaotic Differential Evolution and Quadratic Programming for Economic Dispatch Optimization With Valve-Point Effect," IEEE Trans. on Power Syst. Vol. 21, No. 2, pp. 989-996, May 2006

[8] P. Attaviriyanupap, H. Kita, E. Tanaka, and J. Hasegawa: "A Hybrid LR-EP for Solving New Profit-Based UC Problem Under Competitive Environment," IEEE Trans. on Power Systems, Vol. 18, No. 1, pp. 229-237, Feb. 2003

[9] C. Richter, G. Sheblé: "A Profit-Based Unit Commitment GA for the Competitive Environment," IEEE Trans. on Power Systems, Vol. 15, No. 2, pp. 715-721, May 2000

[10] K. Chandram, N. Subrahmanyam: "New approach with Muller method for Profit Based Unit Commitment," Proc. of IEEE PES. 2008 , pp. 1-8, July 2008

[11] R. Tanese: "Parallel Genetic Algorithm for a Hypercube," in *Proc*. 2*nd Int*. *Conf*. on *Genetic Algorithms*, pp. 177-183, 1987.

[12] N. Mladenovic, P. Hansen: "Variable Neighborhood Search," Computer and Operations Research, pp. 1097-1100, 1997

[13] H. Mori and K. Okawa: "Application of Hybrid Meta-Heuristics Method to Unit Commitment in Power Systems," Proc. of IEEE EPEC. 2008 , pp1-5, Oct. 2008

VIII. Biographies

Hiroyuki Mori was born in Tokyo, Japan on November, 1954. He received the B. Sc., Ph. D. degrees all in Electrical Engineering from Waseda University, Tokyo, Japan in 1979, 1981, and 1985, respectively. From 1984 to 1985 he was a Research Associate at Waseda University. In 1985 he jointed the faculty in Electrical Engineering at Meiji University, Kawasaki, Japan. From 1994 to 1995, he was a Visiting Associate Professor of School of Electrical Engineering at Cornell University, Ithaca, New York, U.S.A. He is currently a professor of Dept. of Electronics and Bioinformatics at Meiji University. Since 2001, he has been the ISAP Board Director. His research interests include voltage instability, power flows, state estimation, load forecasting, system identification, fuzzy, meta-heuristics and artificial neural networks. Dr. Mori is a member of AAAI, ACM, INNS, SIAM and a senior member of IEE of Japan.

Kenta Okawa was born in Saitama-shi, Saitama-ken , Japan on March, 1987. He is now working for the B.Sc. degrees in Electrical Engineering from Meiji University, Kawasaki, Japan. His research interests are system planning and meta-heuristics. Mr. Okawa is a student member of IEE of Japan.