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Combined Heat and Power Economic Dispatch using Civilized Swarm Optimization

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Abstract-Civilized swarm optimization (CSO) is a heuristic search technique based on population concept which can be used to solve various optimization problems involving non-linear cost function having valve point loading. The addition of cogeneration units to the conventional system increases the complexity of the problem leading to satisfaction of multiple constraint for obtaining optimization solution.

Keywords: Civilization; cogeneration; dispatch.

I. INTRODUCTION

Traditional economic load dispatch problems employ quadratic function for cost function for generating units. Evolutionary computational techniques involve metaphorical concepts to solve complex scheduling problems. The basic optimization problem minimize or maximize an objective function subjected to imposed constraints corresponding to the variables of that function. The modern trend involves hybrid approaches (combining heuristic and deterministic methods) for solving various complicated scheduling problems.

II. CIVILIZED SWARM OPTIMIZATION

Civilized swarm optimization (CSO) is a hybrid intelligence method developed by integrating society civilization algorithm (SCA) with particle swarm optimization (PSO). SCA, introduced by Ray and Liew, finds the optimal solution based on intra and intersociety interactions. Kennedy and Eberhart introduced PSO, population based, self-adaptive searching approach, in 1995. In this technique, a randomly initialized array of ideal guides help in finding the solution. CSO is used as an efficient optimizing approach to obtain a solution closer to ideal guides by reducing the minimum distance between them called as Euclidean distance.

III. PROBLEM FORMULATION

The combined heat and power economic dispatch (CHPED) problem of a system determines the heat and power generation so that the generation cost is minimized with all other constraints keeping under their maximum and minimum limits. Assuming convex Input-Output curves for conventional power and heat only units their cost functions will be convex too. The cost function for each unit is obtained when input/output curve is multiplied by cost of fuel burned in that unit. Considering CHP units with convex quadratic cost functions,

$$C_b(H_b) = \alpha_b + \beta_b H_b + \gamma_b H_b^2 \quad (1)$$

$$C_e(P_e) = \alpha_e + \beta_e P_e + \gamma_e P_e^2 \quad (2)$$

$$C_{chp}(P_{chp},H_{chp}) = \alpha_{chp} + \beta_{chp}P_{chp} + \lambda_{chp}P_{chp}^2 + \delta_{chp}H_{chp} + \psi_{chp}H_{chp}^2 + \xi_{chp}P_{chp}H_{chp} \quad (3)$$

$$\mathrm{Min}(F(X)) = \sum_{e=1}^{E} C_e(P_e) + \sum_{chp=1}^{CHP} C_{chp}(P_{chp}, H_{chp}) + \sum_{b=1}^{B} C_b(H_b) \quad (4)$$

Where e, b, chp are the indices of Conventional power units, heat-only units and cogeneration units respectively and E, B, CHP are the number of conventional power units, heat units and combined heat and power units. The equality constraints are the basic load flow equations of active and reactive power. Production & Demand balance Equation for power unit, heat unit and cogeneration unit:

$$\sum_{e=1}^{E} P_e + \sum_{chp=1}^{CHP} P_{chp} = P_D + P_L \quad (5)$$

$$\sum_{b=1}^{B} H_b + \sum_{chp=1}^{CHP} H_{chp} = H_D \quad (6)$$

Generation output of each unit should be laid between its minimum and maximum limits. Capacity Limits of conventional Power unit, heat unit and cogeneration unit:

$$P_e^{min} \le P_e \le P_e^{max} \quad (7)$$

$$H_b^{min} \le H_b \le H_b^{max} \quad (8)$$

$$H_{chp}^{min}(P_{chp}) \le H_{chp} \le H_{chp}^{max}(P_{chp}) \quad (9)$$

$$P_{chp}^{min}(H_{chp}) \le P_{chp} \le P_{chp}^{max}(H_{chp}) \quad (10)$$

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Active power transmission loss is an important factor to be considered and can be calculated by using network loss formula as follows:

$$P_L = \sum_{i=1}^{\beta} \sum_{i=1}^{\beta} P_i B_{ij} P_j \qquad (11)$$

IV. METHODOLOGY

It involves the following steps for solving CHPED problem using CSO approach:

Step 1) Parameter setup
Step 2) Generation of initial civilization
Step 3) Constraint check of cogeneration units and feasible operating region of the combined heat and power economic dispatch problem
Step 4) Initialization of power only units of the civilization
The eth dimension (from e=1 to E) i.e. of power only units of the i^{th} individual of the civilization is initialized as given below to satisfy the generation limit constraint.
Step 5) Initialization of heat only units of the civilization
The bth dimension (from b=E+1 to E + B) i.e. of heat only units of the i^{th} unit of the civilization is initialized to satisfy the heat limit constraint.
Step 6) Initialization of cogeneration units of the civilization
The chp^{th} dimension (from chp=E+B+1 to E+B+CHP) i.e. of the cogeneration units of the i^{th} unit of the civilization is initialized to satisfy the power and heat mutual dependency constraints.
Step 7) Cost function evaluation of each unit of the civilization
Step 8) Updating the best local values for each generating unit
The particles are updated to the best local position to improve the solution for each individual in population using the relations given above.
Step 9) Checking the updated civilization for bound violations

Feasible operating region:
Inequality constraint of the problem also involves a region where the system feasibly operate known as Feasible operating region (FOR) which is satisfied in this paper using Euclidean distance approach. A typical feasible operating region is an irregular quadrilateral as shown in the figure 1.

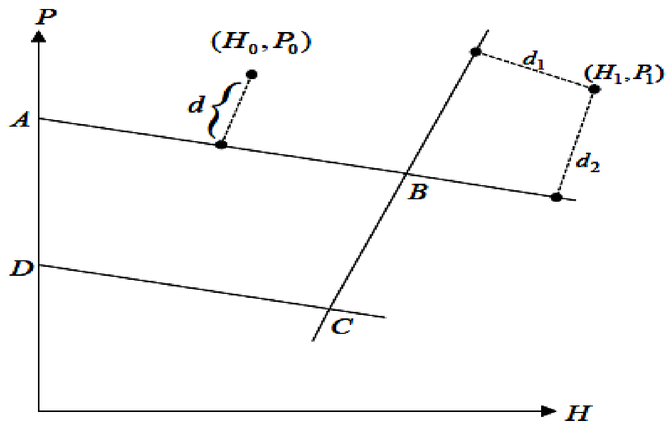

FIG 1: Feasible Operating region for Cogeneration Unit [6].

V. CONCLUSION

The inter and the intra communication between the Society leaders and the civilization leader provides exploration capability to SCA so that society members can exploit a promising region efficiently. But the individuals of SCA follow only their own leaders neglecting their personal experiences. During the earlier optimization stages, PSO explores dynamic space well but cannot able to exploit a feasible region. Thus, it suffer disadvantage of imbalance between local and global searching. In this paper, the proposed approach considers the swarm to be a civilization with societies and is found to be more consistent than the conventional approaches.

VII. REFERENCES

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