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Combined Heat and Power Economic Dispatch using Society Civilization Algorithm

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Abstract- Conventional methods for solving optimization problems can work effectively only if the fuel cost curves of generating units are assumed to be linear and increasing monotonically else they will likely to converge at infeasible solutions. Combined heat and power (CHP) is a consistent approach for solving power and heat energy generation problems. The objective of the combined heat and power economic dispatch (CHPED) problem is to minimize the cost while finding the corresponding scheduled values of heat and power find the optimal point of power and heat generation such that both heat and power equality as well as inequality constraints are met. In this paper, Society civilization algorithm (SCA) approach is adopted for solving combined heat and power economic dispatch problem.

Keywords: Economic load dispatch; Particle; Swarm.

I. Introduction

The practical operating difficulties in a load dispatch problem involves prohibited operating zones and loading effects for combined heat and power (CHP) generation. In the recent years, various methods have been developed such as evolutionary optimization, modified particle swarm optimization (PSO) and anti-predatory PSO to address Economic load dispatch issues. Scarcity of energy resources, increasing power generation costs, and ever-growing demand for electric energy necessitates optimal economic dispatch in today's power systems. The objective function for the CHP problem and corresponding constraint can involve linear or nonlinear functional equations, the constraints can be bound constraints, equality or inequality constraints, or integer constraints.

II. Society Civilization Algorithm

Society civilization algorithm (SCA) introduced by T. Ray and K.M. Liew obtains the optimal solution corresponding to minimized cost function based on intra and inter society interactions. In SCA, individuals are grouped in clusters with better performing individuals of each cluster as society leaders. All such societies constitute the civilization with the best society leader as the civilization leader. In the course of optimization, the society members follow their Society leader and the society leaders follow the civilization leader[1]. Every society involves its better performing individuals constituted as leaders to help others in the society for improving intra society exchange of information. This exchange of information results in the migration of a point toward a better performing point in the cluster. Leaders of a society improve through intersociety information leading to migration of leader[2]. This process of leader migration helps the better performing societies to flourish that correspond to a search around globally promising regions in the parametric space[3]. SCA can be implemented for economic dispatch (ED) problems as below:

Step1.) Initialization of civilization :

The civilization with M individuals is represented as a matrix, i.e.,

$$Civ(t) = [X_1, X_2, ..., X_j, ..., X_M] \text{ with } t \leftarrow 1. \quad (1)$$

$$X_j = [X_{1j}, X_{2j}, ..., X_{NGj}]$$

Step2.) Identifying society leaders:

The individuals of Civ(t) are arranged in the ascending order of PFT values and the first N_S individuals are selected as society leaders, i.e.,

$$SL(t) = [SL_1, SL_2, ..., SL_{Ns}] \quad (2)$$

Step3.) Identifying civilization leader:

Civilization leader is the society leader with minimum objective function value(PFT). For t not equal to 1:
Objective(t) = PFT(CL(t)) if Objective(t − 1) > PFT(CL(t))

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$$\text{Objective}(t) = \text{Objective}(t-1) \quad \text{if Objective}(t-1) \le \text{PFT}(CL(t))$$

Step4.) Identifying society members:

The remaining individuals form a set of society members, i.e.,

$$SM(t) = [SM_1, SM_2, ..., SM_{NR}] \tag{3}$$

The society members set has to satisfy the following condition:

SM(t) $\in$ Civ(t) such that SM(t) $\cap$ SL(t) = Φ

Step5.) Forming societies:

For each SMr $\in$ SM(t), the Euclidean distance between the society member and the society leaders are determined as below:

$$D_S = \sum_{i=1}^{NG} (SM_{ir}(t) - SL_{ik}(t))^2 \quad \text{where } k=1, 2, \ldots, N_S \tag{4}$$

The society member SM_R is assigned to a society 's', if D_S is minimum.

Step6.) Forming new civilization:

The civilization for next generation is initialized as an empty set, i.e., Civ(t+1)← φ. Then the civilization leader at 't' is directly included into the new civilization:

Civ(t + 1) ← Civ(t + 1) U CL(t)

All society leaders, SL_K (t), are moved toward civilization leader and included into the new civilization as below

$$X_K^{SL}(t+1) = CL_K(t) + N(0,\sigma) \times \sum_{i=1}^{N_G} (CL_i(t) - SL_{ik}(t))^2 \tag{5}$$

k=1, 2, . . ., N_S,

All society members, SM_R (t) are moved toward the respective society leaders and included to the new civilization:

$$X_r^{SM}(t+1) = SL_S(t) + N(0,\sigma) \times \sum_{i=1}^{N_G} (SL_{iS}(t) - SM_{ir}(t))^2 \tag{6}$$

r=1, 2, . . ., N_R,

Here s is the society in which SM_R is attached.

Step7.) Termination Step:

If t = tmax, then optimization process is terminated, or else the procedure is repeated from step 2 with t←t+1.

III. PROBLEM FORMULATION

Combined heat and power (CHP) generation proves to be promising than traditional generation methods because of its energy efficient system. Such a dispatch problem is more complicated than conventional ED since here in this problem one or more units generate both power and heat. The combined heat and power economic dispatch problem (CHPED) of a system is to determine the heat and power production so that the system production cost is minimized while satisfying other demands of heat and power meeting all other constraints. Cost function is the sum of cost functions for all the units. Considering CHP units with convex quadratic cost functions. The objective function of the problem is the sum of cost functions for all units:

$$C_b(H_b) = \alpha_b + \beta_b H_b + \gamma_b H_b^2 \tag{7}$$

$$C_e(P_e) = \alpha_e + \beta_e P_e + \gamma_e P_e^2 \tag{8}$$

$$C_{chp}(P_{chp}, H_{chp}) = \alpha_{chp} + \beta_{chp} P_{chp} + \lambda_{chp} P_{chp}^2 + \delta_{chp} H_{chp} + \psi_{chp} H_{chp}^2 + \xi_{chp} P_{chp} H_{chp} \tag{9}$$

$$\text{Min}(F(X)) = \sum_{e=1}^{E} C_e(P_e) + \sum_{chp=1}^{CHP} C_{chp}(P_{chp}, H_{chp}) + \sum_{b=1}^{B} C_b(H_b) \tag{10}$$

For power balance, an equality constraint must be satisfied .Total generated power should be equal to total demand plus total line loss.

$$\sum_{e=1}^{E} P_e + \sum_{chp=1}^{CHP} P_{chp} = P_D + P_L \tag{11}$$

$$\sum_{b=1}^{B} H_b + \sum_{chp=1}^{CHP} H_{chp} = H_D \tag{12}$$

The power output of the power units and the heat output of heat units are restricted by their own upper and lower limits. Capacity Limits of conventional Power unit, heat unit and cogeneration unit:

$$P_e^{min} \le P_e \le P_e^{max} \tag{13}$$

$$H_b^{min} \le H_b \le H_b^{max} \tag{14}$$

$$H_{chp}^{min}(P_{chp}) \le H_{chp}^{chp} \le H_{chp}^{max}(P_{chp}) \tag{15}$$

$$P_{chp}^{min}(H_{chp}^{chp}) \le P_{chp}^{chp} \le P_{chp}^{max}(H_{chp}^{chp}) \tag{16}$$

In case of combined heat and power economic dispatch problem, active power transmission loss can be calculated by using network loss formula as follows:

$$\mathbf{P_L} = \sum_{i=1}^{\beta} \sum_{i=1}^{\beta} \mathbf{P_i B_{ij} P_j} \tag{17}$$

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IV. CONCLUSION

In The strength of the proposed society civilization algorithm is the perfect local-global search balance and can be effectively implemented in order to obtain economic dispatch for cogeneration plants. In this technique, the best-performing particle of the society is the society leader and the intra society interaction between society members and the corresponding society leader wherein the individuals are guided only by others enhances the local searching ability of the society civilization algorithm, i.e. it simulates two movements: society members towards society leader and society leaders towards civilization leader. It has both exploration and exploitation throughout the optimization and has a perfect balance between local and global searching abilities due to which this algorithm can exploit a promising region efficiently for solving the proposed problem.

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