

Teaching Learning Based Optimization for Combined Economic Emission Load Dispatch Problem

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ABSTRACT: “TEACHING LEARNING BASED OPTIMIZATION” is a budding efficient optimization Technic which is proposed in this paper as a tool to optimize the Combined Economic Emission Load Dispatch Problem in Electrical Power System . The key mechanism of this optimization method is dependency of the learners on the teacher . Being a population based optimization technic, this method utilizes a population of solutions for heading towards global solution. The population is taken as a class of learners. The Algorithm has been experimented on two different test systems and the superiority has been revealed in comparison to some other optimization technics.

KEYWORDS: Effect, Teaching learning based optimization, Combined economic emission load dispatch, Genetic algorithm, cost coefficient, emission coefficient, fuel cost

I.INTRODUCTION

One of the most important part of the Electrical Engineering is the Electrical Power System. With the ever increasing popularity of this version of Energy among all layered people , now a days ,it becomes very much necessary for it to be cost effective. Economic load dispatch is an integral part of such cost controlling practice. Initially , Economic load dispatch has involved only optimal power allocation of the generator to cope with the load demand within certain constraints resulting minimum cost. But because of the low capital cost and abundant availability of the fossil fuel, Thermal power plant started mushrooming globally with a dangerous threat to the environment with toxic gases and particulates mixed with residual flue gas to the air. The problem is very rightly taken over and Combined Economic Emission Load Dispatch system(CEED) in a optimized manner has emerged in the field of Electrical Power System Engineering. Both the fuel cost and environmental pollution are supposed to minimize with this approach by allocating optimal power the concerned generators.

Earlier , CEED optimization problems are being solved by Evolutionary programming technic[1], ACO-MSM Approach[2].PSO Technic[3] etc.

Teaching Learning Based Optimization ,a population based technic involving teacher and students' relationship concept, , is comparatively new in the field [4]. The method has speedy computation characteristic in comparison to other method like GA[6],PSO[7],ABC[8].ABC-PSO ,a new optimization method has also been proposed to solve CEED[13].

LITERATURES SURVEY

Gopal Krishnan et al,2011[] gives techniques that were applied to CEED from 2000 to 2010. The challenges encountered by the traditional methods have been also discussed in the paper

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CelalYasaret al,2005[]applies gradient method to solve CEED highlighting easy control of constraints. The paper shows the inconvenience of absence of clearly defined method for the choice of α_G which control the the speed of convergence

Lakshmi A Devi et al,2008[] utilizes evolutionary programming method to solve CEED.According to this paper,Lambda may be used to make the coding of chromosome independent on the number of units.

II.OVERVIEW OF COMBINEDC ECONOMIC EMISSION LOAD DISPATCH PROBLEM

2.1 Fuel and Emission cost Function:

The aim of CEED is to minimize fuel cost and emission cost within all constraints .

The cost function is given by

$$F_i(P_i) = a_i P_i^2 + b_i P_i + c_i \text{-----} \tag{1}$$

$$E_i(P_i) = \alpha_i P_i^2 + \beta_i P_i + \gamma_i \text{-----} \tag{2}$$

$$\text{Min } [F_i(P_i) + E_i(P_i)]$$

Where

$F_i(P_i)$ =Fuel cost function

$E_i(P_i)$ = Emission cost function

P_i =Out put power of generator i

N =Number of generators

a_i, b_i, c_i =cost coefficient of unit i

$\alpha_i, \beta_i, \gamma_i$ =emission cost coefficient

2.2 Constraints

I) Constraints with equality

$$\sum_{i=1}^N P_i(t) = \text{Load Demand} + \text{Transmission Loss}$$

II)Constraints with Inequality

$$P_i^{min} \leq P_i \leq P_i^{max}$$

P_i^{min} & P_i^{max} =Minimum and maximum operating limit of the generatots

III. OVERVIEW OF TEACHING LEARNING BASED OPTIMIZATION TECHNIC (TLBO)

TLBO method is a relationship based method between teacher and students in the class. The method is analogous to the effect of teacher students understanding learning in a class

The population in TLBO is a group of Learners.

TLBO consists of two parts

- i) "TEACHER PHASE"
- ii) "LEARNER PHASE"

Initialization of the population is random within certain limit and the concerned equation is

$$X_{i,j}^0 = X_j^{min} + rand * (X_j^{max} - X_j^{min}) \text{-----} \tag{3}$$

Where rand denotes uniformly distributed random variable within the range (0,1),

X_j^{min}, X_j^{max} = minimum and maximum value of jth parameter

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i) Teacher phase:

The mean parameter of each subject of the learners in the class at generator g is given by

$$M^g = [m_1^g, m_2^g, \dots, m_j^g, \dots, m_D^g]$$

To obtain a new population set of learner

$$X_{new_i}^g = X_i^g + rand(X_{Teacher}^g - T_F * M^g) \tag{4}$$

T_F = Teaching factor between value 1 to 2

If $X_{new_i}^g$ is better than X_i^g in generation g then it replace X_i^g otherwise wise it remains X_i^g

ii) Learner Phase

The students can enhance their knowledge in Learner Phase by interacting with other students or by sharing knowledge

For a Learner X_i^g

Another learner X_r^g is randomly selected with $i \neq r$

Now to set a new vector in learner phase

$$X_{new_i}^g = X_i^g + rand * (X_i^g - X_r^g) \text{ if } f(X_i^g) < f(X_r^g) \tag{5}$$

$$X_{new_i}^g = X_i^g + rand * (X_r^g - X_i^g) \text{ if } f(X_i^g) > f(X_r^g) \tag{6}$$

IV. IMPLEMENTATION OF TLBO METHOD TO CEED PROBLEM

The sequential steps involved in solution of CEED by TLBO are explained below

Step 1: Input the total number of learners, number of subjects offered to the learners, cost coefficients, loss coefficients, load demand and limits of the constraints. Here the number of learners in a class is considered as population and the number of subjects offered to the learner is considered as generators. Each learner indicates a solution for the power generation of the units.

Step 2: Generate the initial population which satisfies the limits and constraints. Each individual (generating units' output) learner is randomly initialized according to equation (1) in the feasible range, which would satisfy the equality and inequality constraints. If any individual violates the limit set that individual at the limiting value. If the equality constraint is violated, discard that individual and repeat the process of initialization until all constraints are satisfied.

Step 3: Objective function of each individual is calculated.

Step 4: In the current iteration the best solution is considered as the teacher and the new value of population is calculated using equations (2) If any new individual violates the limit set that individual at the limiting value. If the equality constraint is violated, discard that individual and repeat the process until all constraints are satisfied.

Step 5: New learners are evaluated according to equation (5) and (6). If any new individual violates the limit set that individual at the limiting value. If the equality constraint is violated, discard that individual and repeat the process until all constraints are satisfied.

Step 6: Stop the process if maximum number of iteration is reached, otherwise repeat from step 4.

V. FLOWCHART OF TLBO ALGORITHM

The flow chart of Teaching Learning based Optimization technic has basically two parts-Teacher's Part and Learner's part

After initialization of the solutions, the best is considered as teacher and the rest of the populations are updated by the teachers

Each better updated solution is accepted to join in the learner phase.

In learner phase, there is random selection of two populations and the worst is updated by other. The updated is rejected if not better than original one.

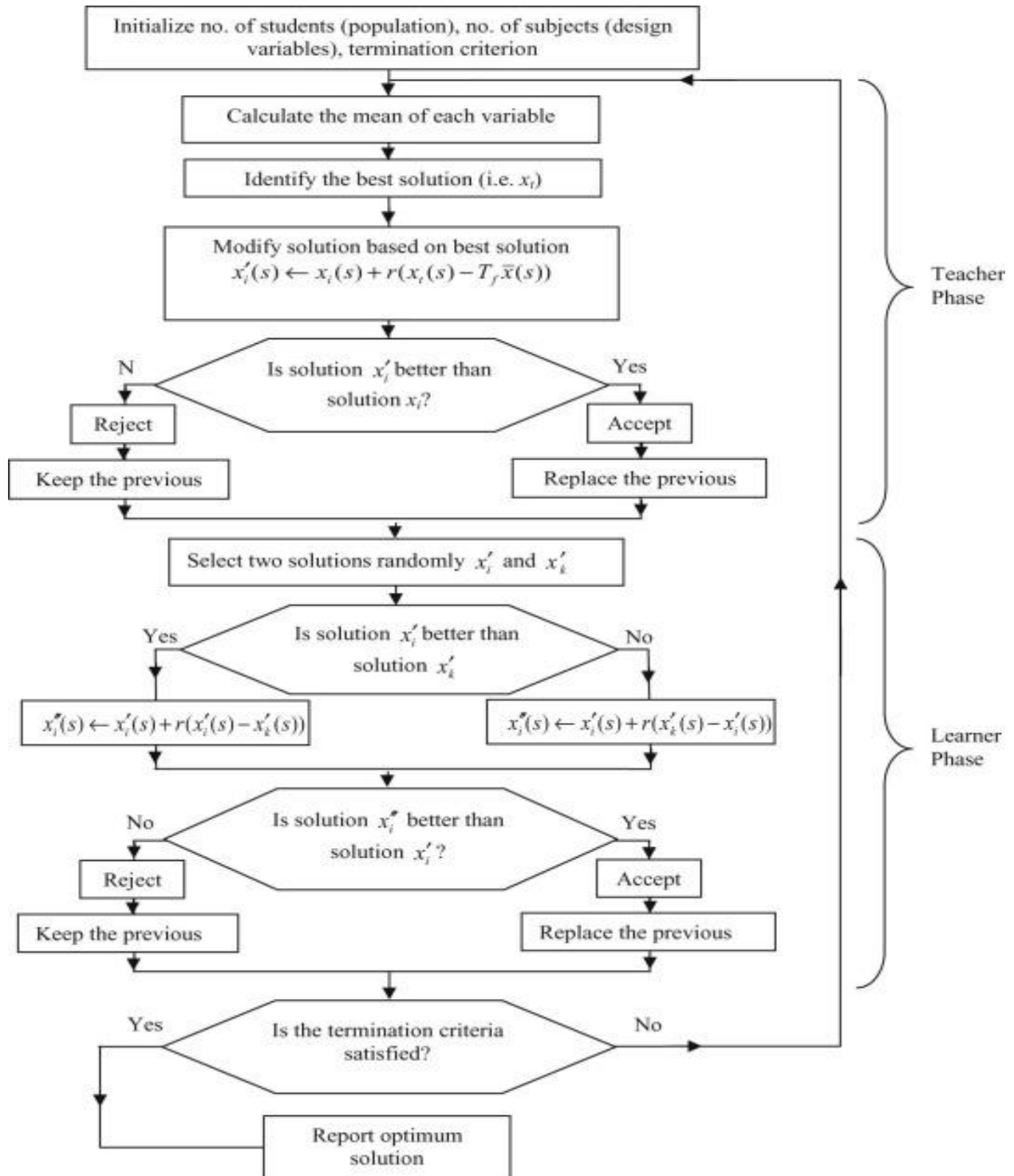
The above all the process are repeated until maximum iteration attain.

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IV. RESULTS AND DISCUSSION

The proposed TLBO algorithm is applied to solve ELD, EED and CEED for two different test cases.

Test case 1: 6 unit system

Test case 2: 10 unit System

Test case 1

The results of solution ELD, EED and CEED by TLBO for 6 unit system are given in Table I, II and III respectively. Results from application of GA are also shown in the table I for comparison. Fuel cost for ELD comes out as 602.406 \$ and Emission for EED comes out as 0.194 lb and for CEED fuel cost and emission are 616.001 \$ and 0.2044 lb. A slight better results in terms of objective function has been obtained by TLBO. Moreover for all the cases in TLBO the numbers of iterations are considerably less than the numbers of iterations in GA.. Fig .1 to .3 shows the convergence characteristics of ELD, EED and CEED for 6 unit system by TLBO.

Table I :Comparison of Economic load dispatch for 6 generators

Generator	Economic load dispatch by GA	Economic load dispatch by TLBO
PG1	0.1183	0.129
PG2	0.3068	0.298
PG3	0.4650	0.455
PG4	1.1025	1.122
PG5	0.5463	0.52
PG6	0.3012	0.314
FUEL COST	602.47	602.406
EMISSION	0.2291	0.2302
Loss	0.0533	0.054
Number of iteration	43	23

Table II:Comparison of Economic Emission Dispatch for 6 generators

Generator	Economic Emission dispatch by GA	Economic Emission dispatch by TLBO
PG1	0.418	0.411
PG2	0.465	0.477
PG3	0.543	0.548
PG4	0.407	0.384
PG5	0.531	0.548
PG6	0.52	0.518
FUEL COST	649.04	651.14
EMISSION	0.1942	0.194
Loss	0.038	0.037
Number of iteration	36	25

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Table III :Comparison on CEED by GA& TLBO for 6 generators

Generator	CEED by GA	CEED by TLBO
PG1	0.193	0.259
PG2	0.34	0.281
PG3	0.48	0.632
PG4	0.71	0.724
PG5	0.693	0.592
PG6	0.449	0.381
FUEL COST	616.01	616.001
EMISSION	0.2044	0.2044
Loss	0.044	0.043
Number of iteration	56	34

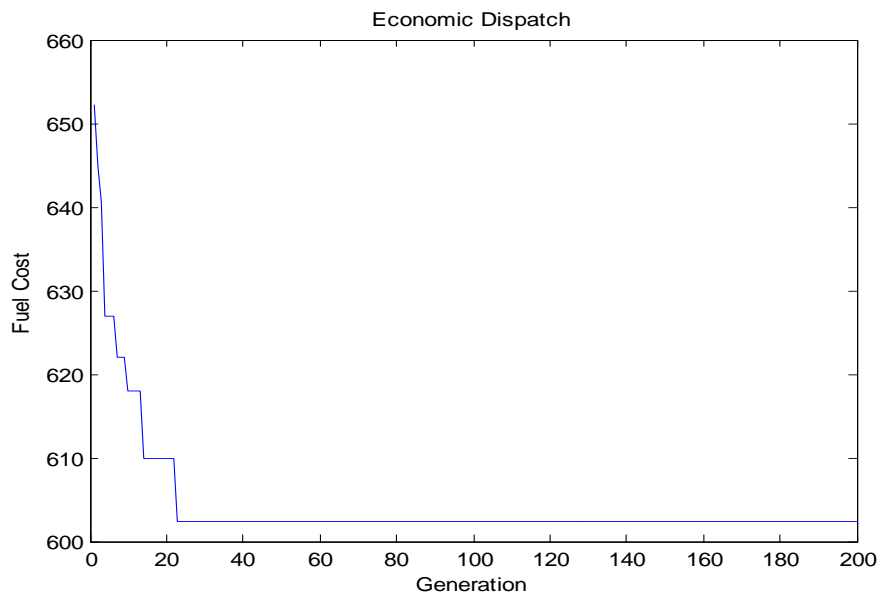


Fig 1. Convergence characteristics of ELD for 6 unit system by TLBO

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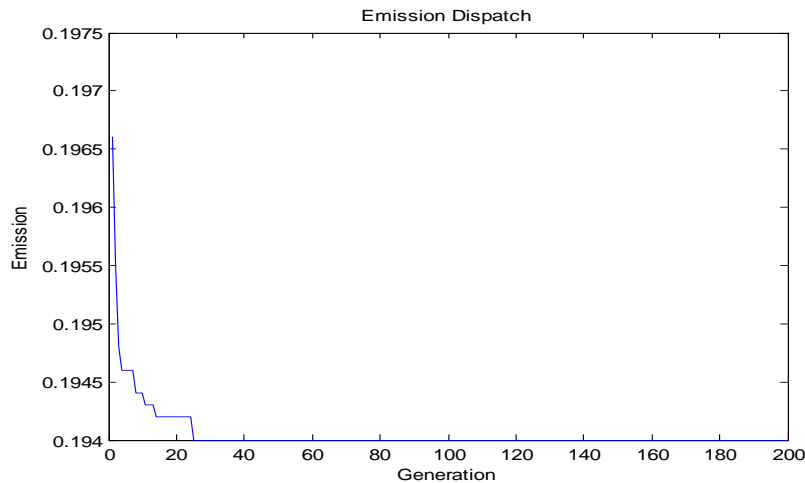


Fig. .2Convergence characteristics of EED for 6 unit system by TLBO

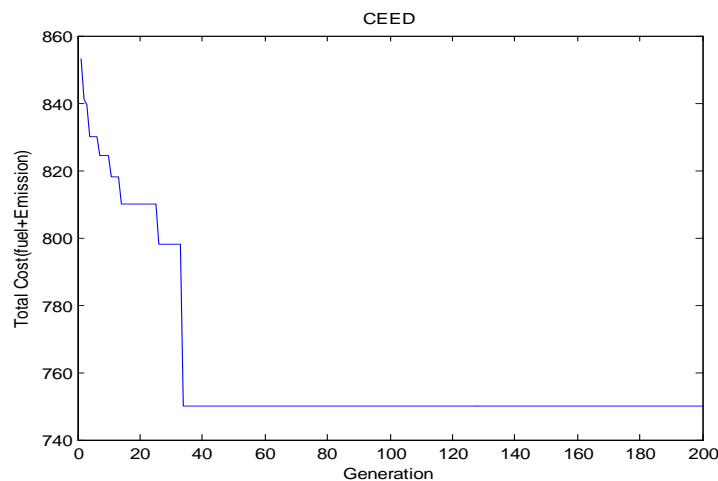


Fig. .3Convergence characteristics of CEED for 6 unit system by TLBO

Test case 2

For 10 unit system the results of solution ELD, EED and CEED by TLBO are shown in Table IV, V and VI respectively. For comparison results from GA application are also given in the table IV. Observations are for ELD, Fuel cost is 111497.632\$ and Emission for EED is 3932.243 lb . For CEED , fuel cost and emission are 113106.894\$ and 4150.496 lb. A slight better results in terms of objective function has been observed by TLBO as compared to GA except for emission in CEED. Also TLBO requires less number of iteration than that required in GA. . Fig .4 to .6 shows the convergence characteristics of ELD, EED and CEED for 10 unit system by TLBO.

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Table IV Comparison of Economic Load Dispatch by GA & TLBO for 10 generators

GENERATOR	Economic Load dispatch by GA	Economic Load dispatch by TLBO
PG1	55	55
PG2	80	79.999
PG3	106.93	106.946
PG4	100.57	100.607
PG5	81.49	81.487
PG6	83.01	83.007
PG7	300	299.999
PG8	340	339.999
PG9	470	469.999
PG10	470	469.999
FUEL COST	111500	111497.632
EMISSION	4571.2	4572.362
LOSS	87.03	87.03
NUMBER OF ITERATION	45	40

Table V: Comparison of Emission Dispatch by GA & TLBO for ten generators

GENERATOR	Economic Emission dispatch by GA	Economic Emission dispatch by TLBO
PG1	55	55
PG2	80	80
PG3	81.96	81.134
PG4	78.82	81.363
PG5	160	160
PG6	240	240
PG7	300	294.485
PG8	292.78	297.27
PG9	401.84	396.77
PG10	391.21	399.576
FUEL COST	116420	1116412.443
EMISSION	3932.3	3932.243
LOSS	81.59	81.595
NUMBER OF ITERATION	42	17

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Table VI : Comparison of CEED by GA and TLBO for ten generators

GENERATOR	CEED by GA	CEED by TLBO
PG1	55	55.888
PG2	80	79.96
PG3	81.14	86.586
PG4	81.22	83.74
PG5	134.34	134.27
PG6	167.5	157.134
PG7	296.83	297.64
PG8	311.58	217.295
PG9	420.34	440.48
PG10	449.16	432.23
FUEL COST	113420	113106.894
EMISSION	4120.1	4150.496
LOSS	84.17	83.223
NUMBER OF ITERATION	40	17

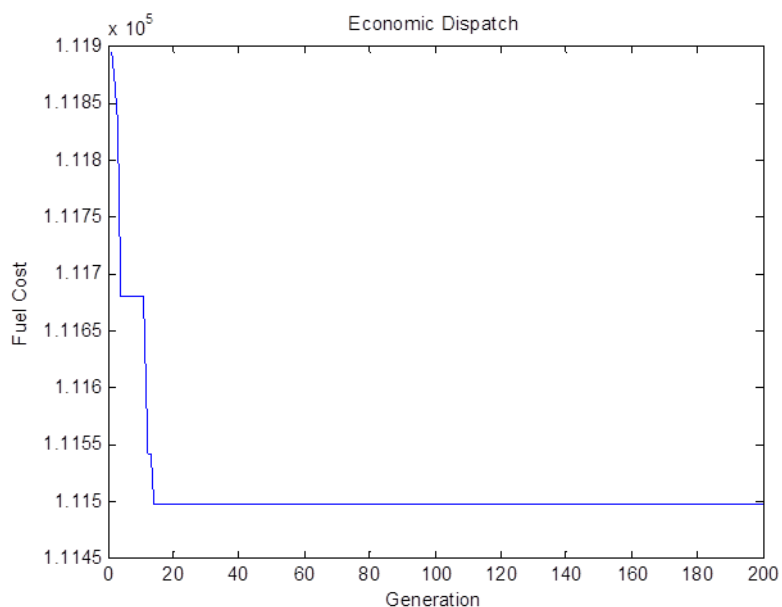


Fig .4-Convergence characteristic of ELD by TLBO for 10 unit system

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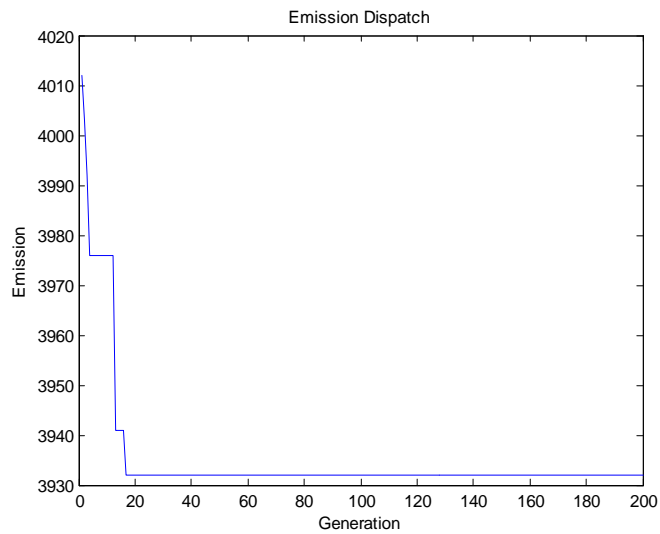


Fig .5-Convergence characteristic of EED by TLBO for 10 unit system

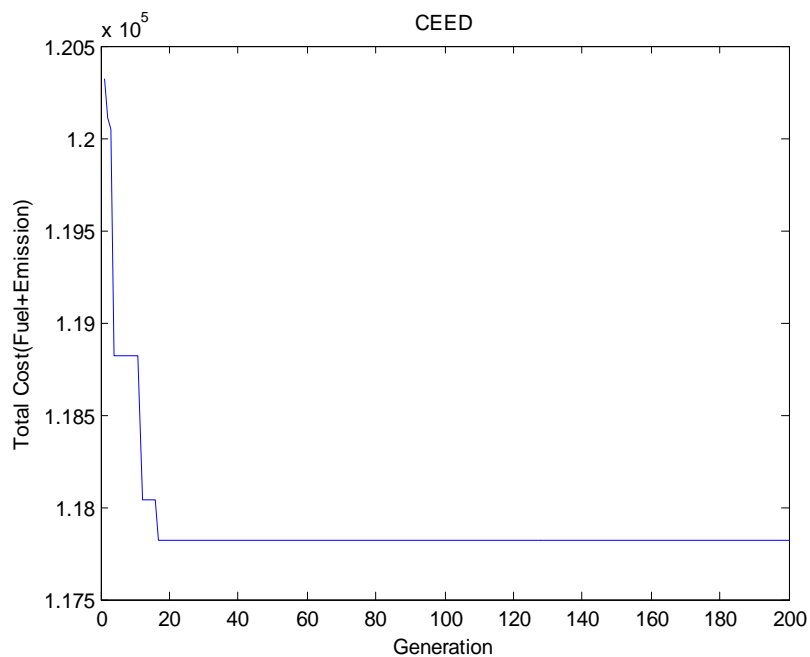


Fig .6-Convergence characteristic of CEED by TLBO for 10 unit system

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VII. CONCLUSION

TLBO has been successfully applied on CEED . It comes out to be a better technic over the counter parts .This technic in both the cases minimize both the fuel cost as well as emission cost satisfactorily.

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