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ABSTRACT

Recent studies in neuroscience, rehabilitation, and machine learning have concentrate on the Electroencephalography (EEG) Brain Computer Interfaces (BCI) as an important domain of research. So, the main purpose of the BCI is to restore communication in the severely paralyzed. Speech is mostly the normal way of communication for individuals; however, in circumstances where audio speech is not ready since the disability or adverse environmental condition, people may go about alternative ways such as augmented speech, that is, audio speech substituted by other forms, such as audiovisual speech, or Cued Speech. Accordingly, BCI for speech communication has been required in several non-medical domains. Selection of the processing technique of the EEG signals at each processing stage has a significant role in determining the success operation of BCI systems. In this survey, we outline a review for ten years ago of the most related speech techniques for pre-processing, feature extraction and classification developed to analyze the EEG signals in order to draw a guide line for researchers to help disabled (speechless) people to use some electronic devices so that such people can communicate with other people like normal persons to reduce their suffer during their daily life.

Keywords—*BCI, EEG, EMG, Imagined Speech, SSI, ICA, SVM, HMM.*

I. INTRODUCTION

Brain Computer Interface (BCI) is a system that connects human brain signals with appliances or devices without requiring of any physical contact, it has been seen as a new way for communication, where the brain activity has been used as a reflected form by electric, magnetic or hemodynamic brain signals to manage external system such as computers, wheelchairs, switches, or neuro prosthetic extensions[1] [2] [3]. BCIs are very useful tools for paralysis persons so there are two types of BCI systems, invasive or non-invasive BCI depending on the measurement method of the brain

activity within BCI. If the place of sensors used for the measurement are placed inside the brain, i.e., under the skull, it is an invasive BCI. While, when the sensors are put on the scalp, it is a non-invasive BCI, they avoid injury risks and associated ethical concerns [4]. The processing stages of non-invasive BCI system are: data acquisition, data pre-processing, feature extraction, classification, device controller and feedback[5]. In invasive BCIs, electrodes or a multiunit electrode array will be placed directly inside the cortex to register electrical potentials for subsequent analysis of the electrocorticogram (ECoG). The resultant brain signals have a high signal-to noise ratio, requiring little user training, and are suitable for the rehabilitation motor functions in disabled patients, while the noninvasive BCIs, have deferent kinds of techniques for brain signals imaging, such as, Magnetoencephalography (MEG) electroencephalography (EEG), Electromyographic signals EMG[6] [7].

II. EEG Applications

Nowadays, EEG have been applied in different fields such as, monitoring alertness, coma, epilepsy, cognitive engagement and brain death, determining the damaged parts after head injury, stroke, cancer, physiology examining and sleep disorder [8]. Person identification[7], and controlling silent speech interfaces[9].

III. RELATED WORKS

In imagined speech recognition field, many researchers had worked on EEG preprocessing, analyzing and classifying. The most related works are reviewed then classified according to the technology used in acquiring the brain signals to three fields: researches with ECoG, with EMG, and with EEG.

A. Electrocorticogram ECoG:

- F. Guenther and J. Brumberg [10] reporting two studies including BMI. The aim of those BMIs was to supply close immediate sound input from a discourse synthesizer to the BMI client. In one study, an intracranial electrode was used to record the neural signal by implanting them in left part of the brain, region concerns with speech, of a patient suffering from paralysis. Those signals were wirelessly transmitted over the scalp and to drive a formant synthesizer, enabling the client to create vowels. The second one, is a pilot study, a healthy volunteer had the ability to drive the formant synthesizer with envisioned developments distinguished utilizing electroencephalography. The outcomes showed the possibility of neural prostheses that can possibly give synthetic speech (near-conversational) for speechless persons.
- C. Herffet. al. [11] a synthesized speech from ECoG activity at the temporal regions at real time had been done. The spectrogram of the audio magnitude, had reconstructed from the neural activity, then the audio waveform from them was built. There was a considerable correlation between the base signal and the reconstructed signal. While audible form of spoken speech was used in the modeling, it considered as first stage to synthesize speech from thoughts.

- G. Anumanchipalliet. al. [12], showed the possibility of producing artificial speech from neural signals of the brain. ECoG signals had been recorded for five volunteers, who submitted for monitoring the intracranial for treatment of epilepsy. Cortical signals had been decoded by recurrent neural network with a clear impersonation for the articulatory dynamics to obtain audible speech synthesize output.

B. ***Electromyographic signals EMG:***

- M. Cleret. al. [13] recorded the facial muscles by using surface electromyography (sEMG) to develop their system to dominate phonemic link and voice synthesizer then tested the system in healthy individuals. They computed the mean rates of transferring the information for a selection of phonemes (ITRs), which was 59.5 bits/min. For the orthographic systems, they also computed ITRs depending on the number of letters needed for spelling the selected word, and reached the results of having mean ITR value of 70.1. So, a comparison for the consequences was made to apply their system on more individuals.

1. Trans cranial Magnetic Stimulation (TMS)

A.Ausilioet. al.[14], TMS had been used on motor area of tongue and lips by applying event-related double-pulse TMS on them. The suggested data showed that an important role may played by the motor system in noisy, surroundings, for speech signal recognition.

2. Electro-Magnetic Articulography (EMA)

- *P*. Heracleous et al. [15], introduced a communication using augmented speech based on EMA. Movements of jaw, tongue, and lips, were traced by EMA and were considered as features to build HMMs. The possibility of recognizing speech (without any audio information) had been examined by conducting the experiences of articulation automatic phoneme discrimination. Outcomes confirmed that phonetic features describing articulation are as discriminating as those characterizing acoustics (except for voicing). Experiments were described and conducted in noisy surroundings using EMA parameters and fused audio. Their results showed that, when EMA parameters were combined with noisy audio speech, the rate of discrimination was better than when applying just a noisy speech.
- M. Wand and T. Schultz [16] used Surface Electromyography (EMG) as a basis for Silent Speech Interface(SSI), the electric activity produced from the articulatory muscles was picked up from the face of user, by the electrodes to decode underlying speech, so the speech would be distinguished even when there were no sound was produced or heard. They used unsupervised session adaptation where a system was first trained with data set from different recorded session and then it was adapted with the required recorded data. They got a great level of accuracy improvements so that their technology may be used in future applications in real-life of SSI.

- Y. Ji et al. [17], updating the Silent Speech Interface (SSI) by using strategy of Deep Learning. A Word Error Rate had been minimized from 17.4% to 6.4%, also the data dimensionality had been reduced by using auto-encoder features. The module applied to two distinctive languages.

3. Imagined speech using EEG:

- J. Brumberg and F. Guenther [18], reviewed many methods for rehabilitation of communication by BCI for persons having severe cases of paralysis, also the dissimilarity between spelling devices and speech prosthesis or direct speech prediction .
- B. Denby et al. [19], condensed the development of the silent speech interface(SSI) from the domains of; automatic speech processing, speech production, speech pathology research, and telecommunications privacy issues. This work followed by the description of experimental systems based on seven diverse kinds of technologies. Pros and cons had been presented for each method.
- A. Riaz et al. [20] considered the state of envisioned and mouthed non-discernible speech, recorded with EEG terminals. They broke down various feature extraction strategies, for example, "Mel Frequency Cepstral Coefficients" (MFCCs), log fluctuation Auto Regressive (AR) coefficients. a pairwise arrangement of vowels was made by utilizing three diverse grouping models dependent on "Support Vector Machine" (SVM), Hidden Markov Models (HMM) and KNN classifier. The proposed procedure was applied on four unique informational indexes with some preprocessing systems, such as, "Common Spatial Pattern" (CSP) separating. The objective of this investigation was to play out a bury examination of various order models and related highlights for pairwise vowel symbolism.
- E. González-Castañeda et al. [21], utilized a strategy of Auditory display, sonification, on EEG signals to get better classification level for EEG signals for imagined speech, was utilized, which enables the describing of EEG signal as a sound sign. They compared the results of sonication processing EEG signals, then observed an improvement in the normal precision rates for signals, it had risen from 48.1% to 55.88%, so the characterization rates improved somewhat.
- K. Mohanchandra and S. Saha [22], concentrated in their work on specking in subvocalized manner, and that was the first trail in using sub-vocal words in EEG with imagined speech. The EEG signals then processed, to synthesize speech from them, with feedback returned to the user to confirm the results. They based on the assumption that, if the speech is undisguised or ulterior it will produce in the brain. The results showed the prediction possibility of the imagined speech. A pairwise correlation was used to minimize the data size and a multiclass SVM was used in classification process of EEG for five words obtained from electrodes.
- K. Brigham and B. Kumar [23], assessed the possibility of individuals' identification using EEG signals during imagined speech (imagining syllables, /ba/ or /ku/). Noise and artifact effect

reduction was done by preprocessing EEG; feature extraction process was done by Autoregressive (AR) coefficients from each channel, and classified with linear SVM. The accuracy of identification was 99.76 % which reflected the possibility of utilizing envisioned discourse EEG information for biometric discrimination because of its solid variety among subjects.

- T. Schultz et al. [24], published a paper that gave an outline of the different ways, inquire about methodologies, and targets for using brain signal for communication via speech.
- P. Kumar et al. [25], proposed a discrimination of envisioned speech from EEG signals. A random forest algorithm was used in features classification coarse level, to classify them either non-text or text classes, then recognition of a finer-level envisioned speech from those classes had been applied. They got an accuracy of recognition about 85.20 at coarse classification, while the accuracy for fine level classification was 67.03%.
- J. S. Brumberg et al. [26], performed a research on using EEG in controlling the synthesize of speech, for the sounds of vowels(/i/, /A/, and /u/). They used three kinds of feedback to the user splitting them to three groups, such that, feedback of unimodal auditory for the speech synthesize, feedback of unimodal visual for the formant frequencies and the other feedback of multimodal. The results showed that the feedback audio-visual type improved the accuracy of the performance.

IV. DISCUSION

After exploring the most related BCI technologies used in acquiring, processing and classifying of the brain signals for inferring the imagined speech; so the following question has to be answered, "What practical techniques can be used in imagined speech to better detection of what is exactly the patient needs to say?". Table (1) gives the appropriate answer, it identifies parameters, degree of complexity, flexibility for some reviewed techniques.

Table (1) Summary of Some Related Researches: Parameters, Complexity and Results

Ref. No..	Parameters	Acquiring Method of brain activity	Classification Algorithm	Results
11.	The extraction of broadband gamma for hearable speech was done by many preprocessing steps like, filtering and down sampling	ECoG	A linear model was applied; since this study was a pilot one.	The study represented the first step for synthesizing imagined speech from neural brain signals
13.	Using the face muscles activities to control the selection of a phonemic interface and voice synthesizer	EMG	Calculating root mean square (RMS) for sEMG signals from eachelectrode every 100 ms and comparingwith the thresholds.	Producing "mean information transfer rates (ITRs) "of 70.1. bits/min i.e., the number of

Ref. No..	Parameters	Acquiring Method of brain activity	Classification Algorithm	Results
				selected phonemes per minute
15.	Movements of jaw, tongue, and lips, were traced by EMA and were considered as features to build HMMs.	EMA	Using of Hidden Markov models (HMMs)	Combining EMA parameters with noisy audio speech, enhanced the rate of discrimination.
16.	Offline Silent Speech Interface (SSI) model.	EMG	Unsupervised neural network for training on the recorded signals.	Good accuracy for testing phase.
17.	Updating Silent Speech Interface (SSI) model	EMA	Deep learning	Reducing Word Error Rate of by 6.4%
20.	Classification for vowels using pairwise by selecting three models of classification based on Hidden Markov Models (HMM), Support Vector Machine (SVM), and k-nn classifier.	EEG	Auto Regressive (AR) coefficients, Mel Frequency Cepstral Coefficients (MFCCs) and log variance	Classification of five vowel sounds
22.	BCI for imagining subvocalized words	EEG	Using of multiclass SVM for the extracted features from scalp electrodes.	Five subvocalized words were classified.
23.	Using speech imagining, for two syllables, /ba/ and /ku/, at different rhythms, to identify persons	EEG	Applying linear model of SVM classifier.	The results showed an accuracy of 99.76% in identification.
25.	Envisioned speech	EEG	Random forest classifier.	Accuracy of recognition was 85.20 %.
26.	Generating formants for the vowels"/i/ /u/ and /A/", by exploiting EEG of MI activity to control formant vector or synthesized in real-time for immediate auditory feedback.	EEG	Using "Hilbert transform" for training and "Kalman filter" for decoding.	Enhancing the performance by using meaningful multimodal feedback.

V. CONCLUSION AND FUTURE GUIDE LINE

In this paper the most related researches with the field of using BCI in inferring the imagined speech has been reviewed. Many methodologies had been used in extracting brain neural activities like; ECoG, EMG, TMS, EMA, and EEG. The researches' results showed that, ECoG had a reasonable accuracy in discriminating the envisioned speech because of its high SNR. Most of the studies worked on using EEG and EMG for recognizing imagined vowels or syllabus of speech, while very few of them worked on using EEG, EMG for recognizing single words, such as (Yes, No, Left,

Right). As a proposal in the next step in this field, we will use EEG signals in designing a smart system as an assist device for paralysis or speechless persons. Fig. 1, shows the processing stages for the proposal, beginning with acquiring EEG signal, second preprocessing them (such as, filtering for the unwanted signals, extracting the most relevant features), third classifying the processed EEG signals are performed to their classes, fourth building a neural network model and training it with deep learning on the required classes, finally processing the more accurate event on a specific program to produce the required speech. The reason of preferring EEG signals for imagined speech research field because of their ease of use, low cost of set-up, good temporal resolution, and portability.

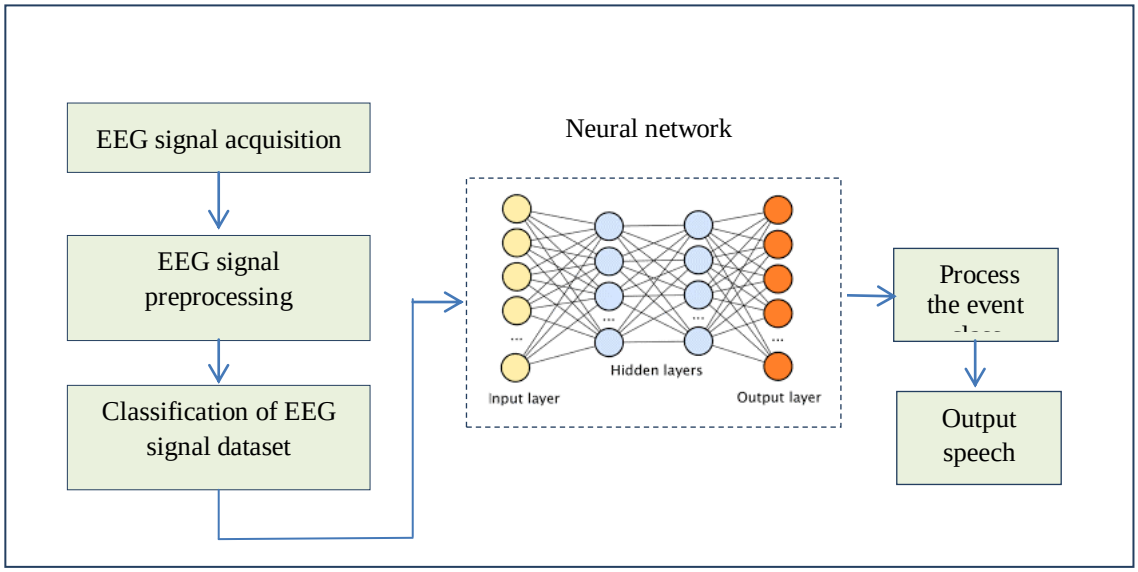

Fig. 1: The processing stages for the proposal

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Optimal Coordination of Over Current Relays Using Teaching Learning Based Optimization Algorithm

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ABSTRACT

Short circuit conditions can happen unexpectedly in any part of a power system at any time due to various physical problems. Such situations cause a large amount of fault current flow through some power system apparatus. The occurrence of the fault is harmful and must be isolated quickly by a set of protective devices. The duty of protective systems is the timely detection of fault and removing it from the power network. One of the most important protective elements that are used in power networks is over current relays. In this article, a new algorithm is presented to solve the optimization problem of coordination of over current relays by using Teaching Learning based Optimization Algorithm. Optimal relay coordination problem is to protect the distribution system within minimum possible time with high reliability. Relay coordination problem is a constrained optimization problem, which can be solved using conventional and heuristic optimization methods. The present work to solved optimal relay coordination problem for IEEE 3 bus and 8 bus test systems using Teaching learning Based optimization (TLBO) algorithm to get the minimum possible operating times while maintaining coordination among all relays in the distribution system.

Keywords:*Teaching Learning Based Optimization Algorithm, Distribution system, optimization, over current relay coordination.*

I INTRODUCTION

In a power system failure of components is inevitable as major components in the power system are subjected to ambient conditions. When a fault happens on any part of the power system, the relays detect the atypical conditions and operate. The relays send trip signal to the circuit breaker which performs the function of circuit interruption. The circuit breaker isolates the defective element from the rest of the system. The main function of protection system is to isolate the minimum possible part of power system at a fault or an atypical condition. When a fault happens in a power system, it should always be detected by two different protection relays. The protection relays are normally chosen Main and Backup protection. Over current relays are mainly used for transmission and sub transmission protection system. To consider comprehensive coordination, an over current relay with over current and finally a distance relay with an over current one when one of them is considered to be main relay and other as backup must be coordinated. In many transmission systems the main protection schemes use the directional over current relays are used as a secondary protection.

When the main protection fails to operate, the first stage backup protection should operate. The determination of time delay for the operation of all backup relays is known as coordination of protection system. Several optimization methods are proposed for coordination of over current relays. The optimal coordination of over current relays has been performed using linear programming techniques such as

- Simplex,
- Two phase simplex,
- Dual simplex methods.

The optimal solution is made by constraints only in. The disadvantage in the above method is that an optimal solution is not obtained if the constrains are not fulfilled. The optimal coordination by evolutionary algorithm may have two problems, miscoordination and lack of a solution. This is because optimization techniques as based on an initial guess and can be trapped in local maximum or minimum values. The intelligent optimization method using Genetic Algorithm does not have this problem. For optimal coordination of relays the critical fault locations have to be determined. The discrimination time between backup and main relays are minimum at critical fault points. The coordination of relays is done based on the constraints derived from values of Δt for critical fault locations. In all existing mathematical coordination methods, fixed characteristics are applied for all over current relays. To achieve optimal coordination the best characteristics for over current relay is required. In this paper the best characteristics of over current relay is selected by genetic algorithm for optimal coordination. In this method the constraints are included in the objective function.

A novel optimization method, 'Teaching–Learning-Based Optimization', is proposed. The method involves less computational effort for large scale problems. The method can be used for engineering design optimization applications.

II PROBLEM FORMULATION

In solution of relays coordination problem achieving minimum operation time and have no mis-coordination is very important.The aim of the coordination problem is to minimize the t operating times of primary and backup relays as follows[1]:

$$\sum_{i=1}^{m} t_i^2 + \alpha 2 \sum_{k=1}^{n} (\Delta_{tbk} - \beta_2 (\Delta_{tbk} - |\Delta_{tbk}|)^2 \quad (1)$$

Wheret_i represents operating time of relay R_i for fault in its primary protection zone, m is the number of primary relays. Moreover, the non-linear and well-known standard inverse definite minimum time characteristic curve based on IEC-60255-3 standard [2] has been considered in this paper. It is defined as

$$t_i = \frac{0.14 \times TMS_i}{\left(I_{c,i} / PS_i\right)^{0.02} - 1} \quad 2)$$

WhereTMS_i and PS_i are the TMS(Time multiplier setting) and PS(Plug setting) of relay R_i, respectively, and $I_{c,i}$ is the fault current passing through the operating coil of relay R_i.

$$\Delta t_{pbk} = t_{bk} - t_{pk} - CTI \quad (3)$$

WhereΔ_{tpbk} is the discrimination time between k_{th} P/B (Primary and backup) relay pairs, n is number of P/B relay pairs, and k indicates each P/B relay pairs which varies from 1 to n. t_{pk} and t_{bk} are the operating time of P/B relays, respectively.α1 and α2 are the positive weight factors to control the first and second terms of objective function.

The constraints subjected to the possible solution of relay coordination can be defined as follows.

A Boundary constraints on TMS

The boundary constraints on TMS can be stated as

$$TMS_{i,\min} \le TMS_i \le TMS_{i,\max} \quad (4)$$

Where$TMS_{i,min}$ and $TMS_{i,max}$ are the minimum and maximum value of TMS of relay R_i, which are provided by relay maker.

B Boundary constraints onPS

The boundary constraints on PS can be stated as

$$PS_{i,\min} \le PS_i \le PS_{i,\max} \tag{5}$$

Where$PS_{i,min}$ and $PS_{i,max}$ are the minimum and maximum values of PS of relay R_i. To make sure that the relay does not malfunction under normal load or small amount of overload condition, the minimum pickup current setting should be equal to or more than 1.25 times of the maximum load current. Similarly, maximum pickup setting should be less than or equal to 2/3 times of the minimum fault current, to make sure that the relay is sensitive to the smallest fault current [2– 4].

C Boundary constraints on operating time of relay

Any relay in the system needs certain minimum amount of operating time, also it cannot be allowed to take more time for the operation [2]. The constraints interconnected to the boundaries on operating time of relay can be stated as

$$t_{i,\min} \le t_i \le t_{i,\max} \tag{6}$$

Where$t_{i,min}$ and $t_{i,max}$ are the minimum and maximum operating time of Ri. In the coordination problem of Directional over Current relays, objective function (OF), coordination constraints and operating time constraints become non-linear due to the non-linear characteristic of relay. Therefore, the coordination problem is referred as complex and non-linear optimization problem and solved by considering large numbers of linear and non-linear constraints. To find the reasonable solution for satisfying these constraints, evolution for the objective function should be well designed.

III TEACHING LEARNING BASED OPTIMIZATION ALGORITHM

The TLBO algorithm is a teaching-learning process inspired algorithm based on the effect of influence of a teacher on the output of learners in a class. The algorithm describes two basic modes of the learning: (i) through teacher (known as teacher phase) and (ii) through interaction with the other learners (known as learner phase). In this optimization algorithm, a group of learners is considered as population and different subjects offered to the learners are considered as different design variables of the optimization problem and a learner's result is similar to the 'fitness' value of the optimization problem. The best solution in the total population is considered as the teacher. The design variables are actually the parameters involved in the objective function of the given optimization problem and the best solution is the best value of the objective function. The working of TLBO is divided into two parts, 'Teacher phase' and 'Learner phase'. Working of both the phases is explained below.

A Teacher Phase

It is the first part of the algorithm where learners learn through the teacher. For the period of this phase, a teacher tries to increase the mean result of the class in the subject taught by him or her depending on his or her capacity. At any iteration i, assume that there are 'm' number of subjects (i.e., design variables), 'n' number of learners (i.e., population size, k = 1, 2…… n) and Mj,i be the mean result of the learners in a particular subject 'j' (j = 1, 2,…, m) The best overall result $X_{total\text{-}kbest,I}$ considering all the subjects together obtained in the total population of learners can be considered as the result of best learner kbest. However, as the teacher is usually considered as a highly learned person who trains learners so that they can have better results, the best learner identified is considered by the algorithm as the teacher. The difference between the existing mean result of each subject and the corresponding result of the teacher for each subject is given by,

$$Difference\_Mean_{j,k,i} = r_i(X_{j,kbest,i} - T_F M_{j,i}) \tag{7}$$

Where, $X_{j,kbest,i}$is the result of the best learner in subject j. T_F is the teaching factor which decides the

value of mean to be changed, and r_i is the random number in the range [0, 1]. Value of T_F can be either 1 or 2. The value of T_F is decided randomly with equal possibility as,

$$T_F = \text{round}[1+\text{rand}(0,1)\{2-1\}] \tag{8}$$

TF is not a parameter of the TLBO algorithm. The value of TF is not given as an input to the algorithm and its value is randomly decided by the algorithm using Eq. (8). After conducting a number of experiments on many benchmark functions it is concluded that the algorithm performs better if the value of TF is between 1 and 2. However, the algorithm is found to perform much better if the value of TF is either 1 or 2 and hence to simplify the algorithm, the teaching factor is suggested to take either 1 or 2 depending on the rounding up criteria given by Eq. (8). Based on the $\text{Difference\_Mean}_{j,k,i,}$ the existing solution is updated in the teacher phase according to the following expression.

$$X'_{j,k,i} = X_{j,k,i} + Difference\_Mean_{j,k,i} \tag{9}$$

Where, $X'_{j,\,k,\,i}$ is the updated value of $X_{j,\,k,\,i.}X'_{j,\,k,\,i}$ is accepted if it gives better function value. All the accepted function values at the end of the teacher phase are maintained and these values become the input to the learner phase. The learner phase depends upon the teacher phase.

B Learner Phase

It is the second part of the algorithm where learners increase their knowledge by interacting among themselves. A learner interacts randomly with other learners for increase his or her knowledge. A learner learns new things if the other learner has more knowledge than him or her. Considering a population size of 'n', the learning occurrence of this phase is explained below Randomly select two learners P and Q such that $X'_{\text{total-P,i}} \neq X'_{\text{total-Q,i}}$ (where, $X'_{\text{total-P,i}}$ and $X'_{\text{total-Q,i}}$ are the updated function values of $X_{\text{total-P,i}}$ and $X_{\text{total-Q,i}}$ of P and Q, respectively, at the end of teacher phase)

$$X''_{j,p,i} = X'_{j,\mathrm{P},i} + r_i(X'_{j,\mathrm{P},i} - X'_{j,\mathrm{Q},\mathrm{i}}), If\ X'_{total-Q,j} < X'_{total-P,\mathrm{i}} \tag{10}$$

$$X''_{j,p,i} = X'_{j,\mathrm{P},i} + r_i(X'_{j,\mathrm{Q},i} - X'_{j,\mathrm{P},i}), If\ X'_{total-Q,I} < X'_{total-P,i} \tag{11}$$

$X''_{j,\mathrm{P,I}}$ is accepted if it gives a better function value. The Eqs. (11) and (12) are for minimization problems. In the case of maximization problems, the Eqs. (12) and (13) are used.

$$X''_{j,p,i} = X'_{j,\mathrm{P},i} + r_i(X'_{j,\mathrm{P},i} - X'_{j,\mathrm{Q},\mathrm{i}}), If\ X'_{total-Q,j} < X'_{total-P,\mathrm{i}} \tag{12}$$

$$X''_{j,p,i} = X'_{j,\mathrm{P},i} + r_i(X'_{j,\mathrm{Q},i} - X'_{j,\mathrm{P},i}), If\ X'_{total-P,I} < X'_{total-Q,i} \tag{13}$$

Teaching-learning-based optimization (TLBO) is a population-based algorithm which simulates the teaching-learning process of the class room. This algorithm requires only the common control parameters such as the population size and the number of generations and does not require any algorithm particular control parameters.

C Steps for the TLBO

The following steps give explanations to the TLBO algorithm.

Step 1: Initialize the population size or number of students in the class(N), number of generations (G), number of design variables or subjects (courses) offered which coincides with the number of units to place in the distribution system (D) and limits of design variables (upperU_L, and lower L_L, of each case).

Classify the optimization problem as: Minimize f(X), where f (X) is the objective function X is a vector for design variables such that $L_L \leq X \leq U_L$.

Step 2**:** Generate a random population according to the number of students in the class (N) and number of subjects offered (D).

Step 3:Calculate the average grade of each subject offered in the class.

Step 4:Based on the grade point (objective value) set the students (population) from best to worst.
Step 5:Change the grade point of each subject (control variables) of each of the individual student.
Step 6:Every learner improves grade point of each subject through the mutual interaction with the other learners. Each learner interacts randomly with other learners and hence facilitates knowledge sharing

D Flow chart for the TLBO

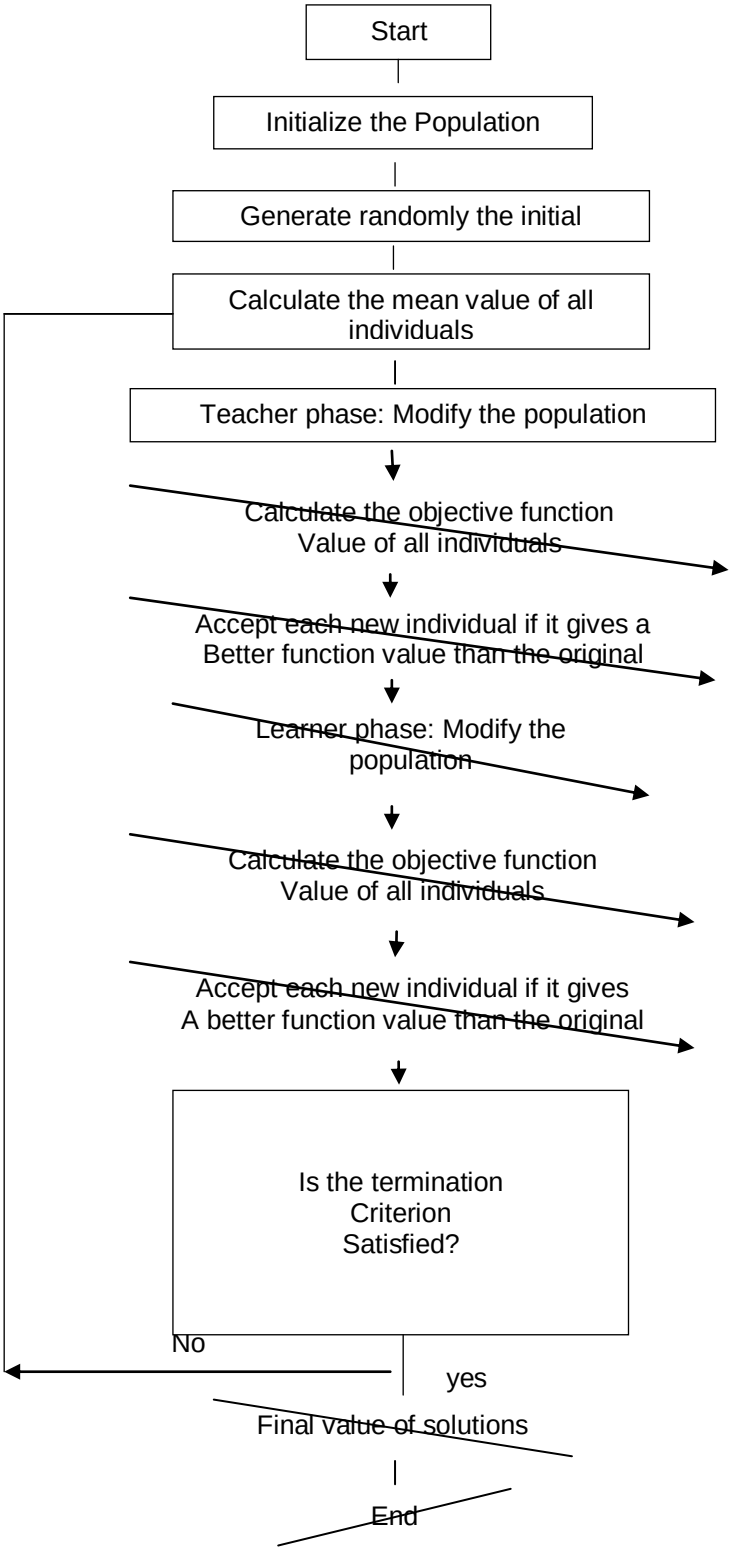

Fig 1 : Flow diagram of the TLBO algorithm

IV SYSTEM UNDER STUDY

System under study that is shown in Fig. 2 consists of 3 lines, 3 buses 2 Generators and 6 relays and fig 3 consists of 7 lines, 8 buses, 2 generators, 2 transformers and 14 relays [5-8].The information data of the network is given in Tables 1–3.

TABLE 1 :3Φ faults of the 3 – bus system

Primary (R_i)	*Fault current*	*Backup (R_j)*	*Fault current*	*CTR*
R_1	1978.90	R_5	175	300/5
R_2	1525.70	R_4	545	200/5
R_3	1683.90	R_1	617.22	200/5
R_4	1815.40	R_6	466.17	300/5
R_5	1499.66	R_3	384	200/5
R_6	1766.30	R_2	154.34	400/5

TABLE 2 :3Φ faults of the 8 – bus system

Primary (R_i)	*Fault current*	*Backup (R_j)*	*Fault current*	*CTR*
R_1	3232	R_6	3232	1200/5
R_2	5924	R_1	996	1200/5
R_2	5924	R_7	1890	1200/5
R_3	3556	R_2	3556	800/5
R_4	3783	R_3	2244	1200/5
R_5	2401	R_4	2401	1200/5
R_6	6109	R_5	1197	1200/5
R_6	6109	R_{14}	1874	1200/5
R_7	5223	R_5	1197	800/5
R_7	5223	R_{13}	987	800/5
R_8	6093	R_7	1890	1200/5
R_8	6093	R_9	1165	1200/5
R_9	2484	R_{10}	2484	800/5
R_{10}	3883	R_{11}	2344	1200/5
R_{11}	3707	R_{12}	3707	1200/5
R_{12}	5899	R_{13}	987	1200/5
R_{12}	5899	R_{14}	1874	1200/5
R_{13}	2991	R_8	2991	1200/5
R_{14}	5199	R_1	996	800/5
R_{14}	5199	R_9	1165	800/5

TABLE 3 : Optimization data for the 3 bus and8 bus systems

Type of bus	*TMS Min*	*TMS max*	*PS Min*	*PS Max*	*PS Mode*	*CTI (sec)*
3 - bus	0.1	1.1	1.5	5.0	Discrete	0.2
8 - bus	0.1	1.1	0.5	2.5	Discrete	0.3

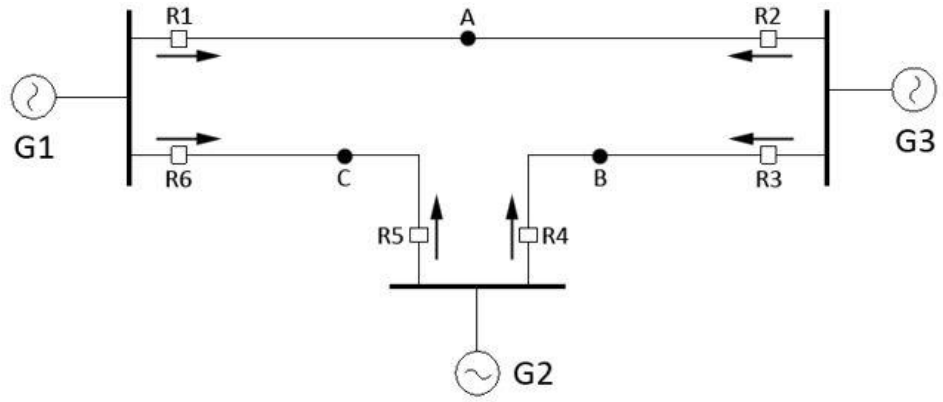

Figure 2 : 3 Bus Test System

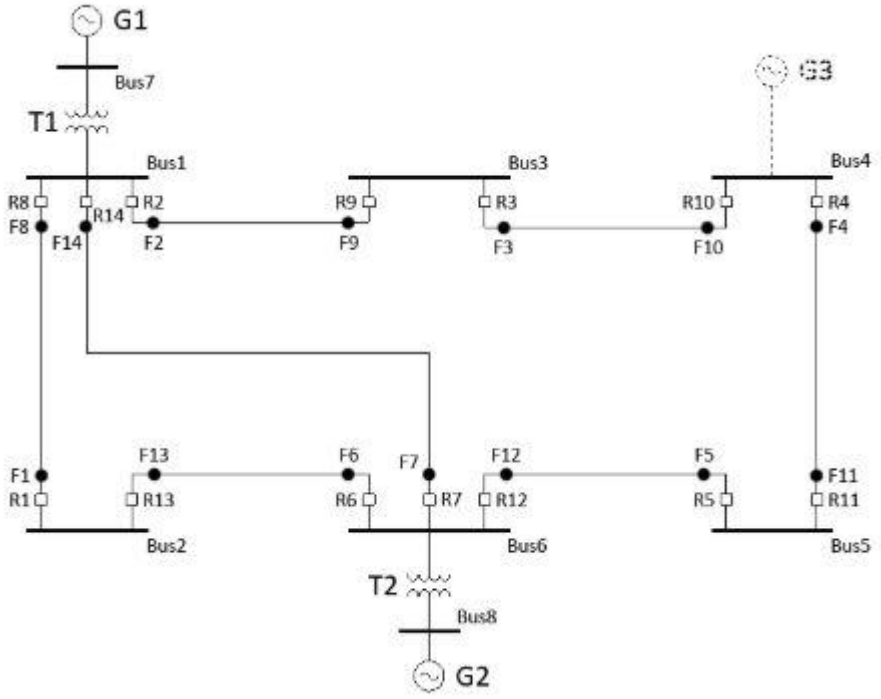

Figure 3 : 8 - Bus Test System

V RESULTS AND DISCUSSIONS

TABLE 4:TLBO parameters

TLBO parameters	*Value*
α_1	1
α_2	1
β_2	100
Iterations	100
N	10
D	2
CTI	0.2

As seen in table 4, the CTI depends upon the types of relays, operating time of circuit breaker, relay error and safety margin. Typically, the CTI is selected between 0.3 and 0.5s for electromechanical relays, whereas it is considered between 0.1 and 0.2s in microprocessor-based relays. α1, α2are the positive weight factors to control the first and second terms of objective function. Where β2 used to consider mis coordination, N, D are population size and number of design variables.

TABLE 5: Total operating time of P/B relays

3 bus - system	6.0925
8-bus system	14.1193

From table 5, it shows the total operating time of primary and backup relays. It gives the minimum total operating time of primary and backup relays. By reducing the discrimination time of P/B relay, the operating time of backup relays is also minimized.

TABLE 6: Relay settings obtained by objective function for IEEE 3 – bus system

Relay	*TMS*	*PS*
R_1	1.0760	1.5245
R_2	1.0927	1.8962
R_3	1.0812	4.1332
R_4	1.0932	1.6205
R_5	0.9397	1.5000
R_6	0.9953	1.5024

TABLE 7: Relay settings obtained by objective function for IEEE 8 bus - system

Relay	*TMS*	*PS*
R_1	1.1000	2.5000
R_2	1.0240	2.5000
R_3	1.1000	0.5000
R_4	1.1000	2.5000
R_5	1.1000	2.3772
R_6	0.1000	2.4322
R_7	1.1000	2.5000
R_8	1.1000	0.5000
R_9	1.1000	2.5000
R_{10}	1.1000	2.5000
R_{11}	0.9856	0.5000
R_{12}	1.0193	2.5000
R_{13}	1.0904	2.4049
R_{14}	1.1000	0.7798

From table 6 and 7, it shows the TMS and PS values of the relays. Table 5, gives the minimum operating time of the P/B relays, that corresponding values of TMS and PS are taken from table 8.

TABLE 8: Discrimination time of the P/B relays for 3 bus - system

Relay	**Discrimination time (Δ_{tb})**
R_1	0.3367
R_2	0.0076
R_3	0.0522
R_4	0.0613
R_5	0.0337
R_6	0.3378

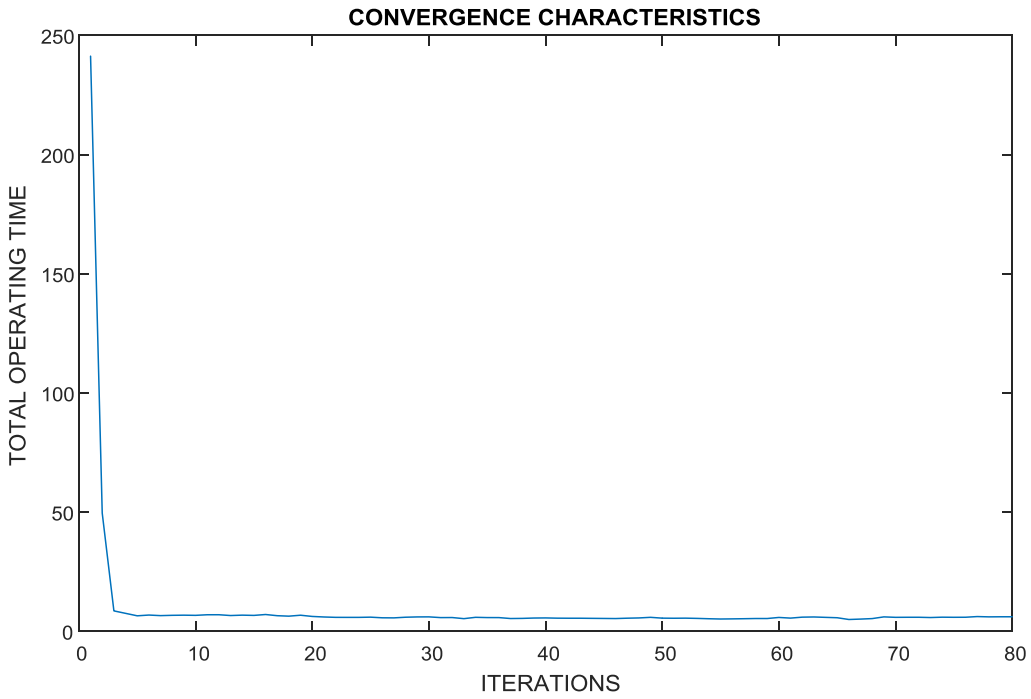

Fig 4: Convergence of TLBO for IEEE 3-bus network

Fig 4 shows the convergence of TLBO for IEEE 3-bus network. The convergence of the TLBO was plotted between objective function vs .number of iterations. In fig 4 we were observed gradually decrease of the objective function and it gives the better operating time of the relays.

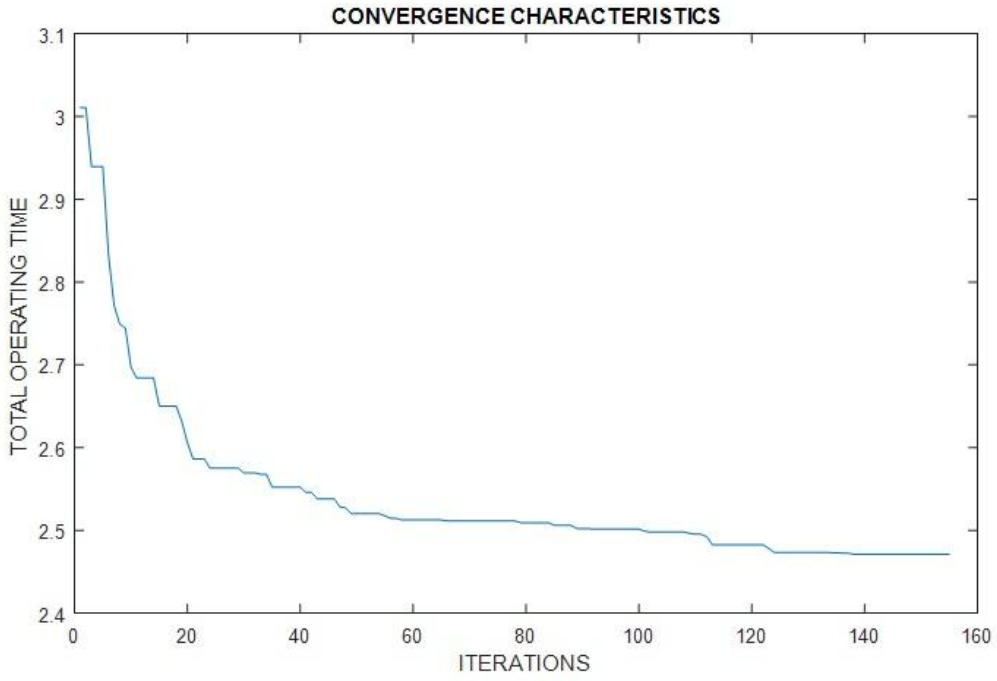

Fig 5: Convergence of TLBO for IEEE 8-bus network

Fig 5 shows the convergence of TLBO for IEEE 8-bus network. The TLBO method improves the performance of convergence characteristics, results in a less operating time compared to other works.

VI CONCLUSION

The Teaching Learning Based Optimization process can be used to solve the optimal placement and sizing problems of Distributed Generation units in various systems, in particular it can be implemented for radial distribution systems. In relay coordination optimization process, minimizing relays operating time is very important. In this paper Teaching Learning Based Optimization Algorithm is applied for relays coordination using IEEE 3 bus and 8 bus test systems. The results showed that the proposed TLBO technique is capable of finding superior TDS, PMS settings and minimum operating time of the P/B relays. This method works on the effect of influence of a teacher on learners.

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Design of A Fertilizer System That Can Be Used in The Hose Reel Irrigation Machines

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ABSTRACT

In case the soil cannot supply water and plant nutrients enough for the plant, the actions to be taken are irrigation and fertilization. In this study, the design of a device that allows the fertilizer to apply fertilizer at the same time while irrigation with the Hose Reel Irrigation Machines used in agricultural irrigation was designed. In this design, a dosing unit and a fertilizer tank were added to the irrigation system, allowing a certain amount of fertilizer to be added into the water. The design has been tested both in the laboratory and in field conditions. In the laboratory, it has been observed whether sealing and applying correct amount of fertilizer. In field applications, food coloring was applied instead of fertilizers and the amount of paint on filter papers was evaluated. According to the results obtained, the use of dosing pumps in hose reel irrigation systems gave positive results in order to increase irrigation water use and fertilization efficiency. When the field distribution was analyzed, the coefficient of variation varied between 21-38% and it was stated that this was an acceptable value.

Keywords: Hose Reel, Irrigation, Fertilizer, Dosing, Pump

I. INTRODUCTION

In order to maintain the vital functions of the plants in agricultural production and to obtain high efficiency, the nutrients needed by the plants must be dissolved in roots. Water plays an important role in dissolving the nutrients in the soil and delivering them from the root to the stem, branches and leaves of the plants.

It is the technique of sprinkler irrigation, in which the water is sprayed into the air with a certain angle and pressure, and dropped in the form of fine droplets on the soil and the crop by its own weight. It can be used with the water source with lower flow rate conditions than surface irrigation methods. Due to the fact that the necessary parts can be provided and controlled during application, that method can be widely used in the world.

Among the sprinkler irrigation systems, the hose-reel irrigation machine is a system that provides easy use by reducing the cost with less labor. It is much more economical than other irrigation methods in terms of cost. It can work at low pressures and prevents hardening of the soil and damaging the crops with proper irrigation. It allows irrigation of more than one field area. It is operated under pressure with the help of plastic hoses from water sources.

Today, one of the precautions we can take against the rapid increase of the input costs such as fertilizer, diesel, labor is to increase field efficiency by %20-50 and increasing our profit by producing export quality products. Regarding this, irrigation with methods such as sprinkler irrigation both has advantages and is important in terms of using water resources and water saving, and it should be made more widespread in our country. When the fertilizer applying function is installed on these systems, success will increase even more.

For the sustainable use of water in agriculture, it is necessary to increase the use efficiency of water [1]. To achieve this goal, factors such as irrigation systems that use water efficiently, appropriate irrigation timing, watershed management, drought-resistant plant growing, dry farming, mulch usage, compost and organic farming should be taken into consideration. One of the most important ways is pressure irrigation systems such as drip and sprinkler irrigation. In this way, the root part of the plant can be irrigated directly. Fertigation is the application of plant nutrients, such as liquid or solid fertilizers, together with irrigation systems to soil or plant root zone. It is possible to apply fertilizers with all irrigation systems in fertigation.

Fertilization systems used in agriculture are mostly used in conjunction with the plants planted, fruit trees and drip irrigation systems. In field agriculture, sprinkler irrigation systems are used in the plants planted in many continuous rows, especially cereals. However, fertigation is not applied. Due to the almost constant flow in drip irrigation systems, sufficient amount of fertilizer can be applied at the required time and at the required amount. Thus, the amount of fertilizer, labor and time needed for application are saved and the nutrients needed by the plant during the growth period provided. At the same time, an environmentally friendly application is made by preventing environmentally harmful substances from accumulating in the soil. Miller et al. (1976) and Locascio et al. (1985) stated that the application of water and fertilizer with the drip irrigation is important in terms of increasing the efficiency and quality, as well as increasing the use efficiency of water and fertilizer. Increasing the use efficiency of water and fertilizer is important for human health as well as for protecting the environment and natural resources. Homogeneity is also excellent in fertilizer applications with sprinkler irrigation methods [11].

As can be seen, the main basis of the application is to supply the water and plant nutrients needed for the plant without creating excessive water demand. Loss of nutrients due to surface runoff and

washing from the soil surface can be prevented with this method. Since only the part of the plant is wetted, water and fertilizer saving is provided, while the water and nutrients required by the plant are met during the development period.

Some researchers have reported that the plant yield has increased significantly with the frequent fertigation and fertilizer application in the soil with low nutrient concentrations, and the main reason for this increase in yield is due to regular nutrient intake [21, 27]. In previous studies, it has been determined that plant nutrients and chemicals used in agricultural production can be given frequently, even continuously, with irrigation water in drip systems, and fertilizer and chemical applications efficiency is higher compared to other systems [10].Fertigation enables the application of irrigation water and soluble fertilizers and other chemicals together, uniform (balanced distribution) and more effective [19, 17].

It is stated that traditional fertilizer application methods (spreading or band application) are not as effective as fertigation, and fertigation provides both an effective and cheap way in providing water and nutrients to plants [8, 9]. In general, plants react better to fertigation than band and spreading applications. Fertigation can be advantageous in the application of fungicides and microelements in a mixture for a clean environment. by eliminating the use of these chemicals separately and they can provide osmotic pressure [14]. Similarly, Brian (1995) reported in his study on grapefruit that he achieved higher fertilizer use efficiency compared to traditional fertilization with fertigation application.

Solaimalai et al. (2005), Darwish et al. (2002), in their study on potatoes, report that fertigation provides higher water and nutrient use efficiency compared to traditional fertilization method.

A couple of investigators have demonstrated that the efficacy of nutrient uptake in fertilization of cotton (Gossypium spp), tomato (Lycopersicon esculentum Mill), sugarcane (Saccharum officinarum L.), strawberry (Fragaria ananassa Duch) and broccoli (Brassica oleracea L.) plants increased by 15–50%. and reported that they increased the yield by 7–49% [3, 7, 12, 26, 27]..

The aim of this study is to develop a system that will reduce excess water consumption in agricultural irrigation for the hose-reel irrigation machines. For this purpose, a system including dosing pump, fertilizer tank and fittings has been designed. Later on, this system was evaluated by examining the spray distribution in the field conditions.

II. MATHERYAL AND METHODS

Theoretical studies have been carried out within TekirdağNamık Kemal University Department of Biosystem Engineering. Assembly and experiments are carried out in IrtemTarimMakine Co.,Hayrabolu,Tekirdag,Turkey and the trial fields of the company. The water used for irrigation of the trial parcel was supplied from the deep well with a flow rate of 120 m3/h, located on the border of the trial field.

Fertilizer system consists of a tank, dosing pump, pipes and connections. While taking the water from the source and pumping it into the system, the pressurized liquid enters the fertilizer tank with the help

of a pipe and from there, with the help of the dosing unit, the specified amount is transferred back to the system together with the fertilizer.

When planning all system components, the necessary fertilizer norm was taken into consideration and the dosing pump was selected. Since the hose reel irrigation machines are used for irrigation of plants such as clover, corn, beet, 30 kg / da fertilizer norm, which is the maximum amount applied for those crops was used in these calculations. The suitability of the pump was decided by comparing the pump characteristics and literature information to be used in the system. Using these data, a pump with a flow rate of 2.5 m3 / h (dosing rate: 1: 500) was selected, which can operate between 0.2-8 bar. Then the components were assembled. Mixrite dosing pump with a flow rate of 20-2500 L/h produced by TEFEN Co. has been selected.The pump is connected to the irrigation pipe in the upstream and downstream directions.

The rate of fertilizer to be added on the pump can be adjusted. In addition, the plastic pipe is attached to the suction line of the dosing pump to suck the fertilizer inside the tank. It is attached to the system externally by a pipe. A ball valve is placed between the entry and exit points. Before the inlet and outlet, 2 manometers are connected to control the pressure. Valves are also assembled inlet and outlet of the pump.

A plastic tank is prepared so that the dosing pump can take fertilizer and store the fertilizer. The tank is 100 liters and 40 x 77 cm in size, and the cover can be clamped with a clamp (Fig. 1).

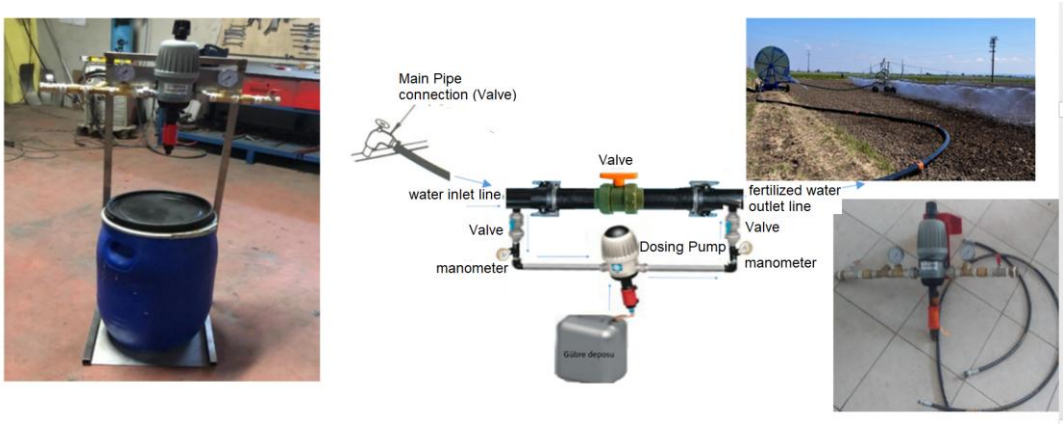

Fig. 1. System installation

The system is operated in different dosages, workshop conditions (0.5-1.0-4.0-6.0-8.0 bar), and its sealing and success have been tested. The performance of water suction, injection, taking fertilizer liquid from the fertilizer tank at the desired rate and injecting this ratio to the system were checked. Then, it was decided to start field trials by connecting to the hose reel irrigation machine system.

The hose reel irrigation machine used in tests produced by Irtem Tarim Makine Co. (Fig 2). It can be used with boom or guns. In general, it consists of the hose reel chassis, gearbox group, axle group, main chassis, lifting piston, tires, hose, water turbine, irrigation gun, boom chassis and boom carrying cart. The main dimensions of the irrigation machine with the hose reel (width x length x height) is 2310 x 3000 x 2250 mm. 300 m of Polyethylene pipe that can be wrapped in a hose reel with a diameter of 90 mm and a thickness of 8 mm is used. The hose reel irrigation machine has a boom width of 45 m

and 30 spray nozzles on it. Each spray nozzle has a diameter of 6 mm. There is also a watering gun at the ends. In this way, it makes irrigation up to 60 m. The boom height can be adjusted between 80-220 cm. 1,8 hectares of land can be irrigated at one time. The speed of self recovery after the machine is turned on is 10-100 m / h.

Fig. 2. The hose reel machine

The field in which the field trial will be carried out was plowed in autumn, it was leveled by curing equipment. Residue distribution test was carried out to determine whether correct fertilization was done. In order to test the homogeneity of the spray, filter papers were placed at certain points in the test area at 5 m intervals. Tartrazine (20 g / L), a water-soluble food coloring, was used as a tracer in the spray liquid. Tartrazine is thought to be suitable for deposit evaluation due to its high recovery rate [20]. In the trials, trace substance norm was used as 4000 g / ha.

In the experiments, filter papers (Schlicher&Schuell 589) with a quarter circle slice with an area of 10x20 cm2 were used as the sample surface. Painted liquid discarded by irrigation was sprayed on filter papers. These papers were kept in water after the application and it was ensured that Tartrazine paint passed to water at a high rate. It is perpendicular to the direction of progress in the trial area and the filter papers are placed under the boom wings (right and left) for 3 repetitions at 5 m intervals. Considering the number of spray nozzles and gun wetting area, 34 filter papers were placed. A total of 102 filter papers were used. In this study, colorimetric method was used to measure the dye concentration in filter papers in the laboratory [2].After fertigation, the researchers waited 15 minutes for the filter papers to absorb the paint well. Then it was wrapped in aluminum foils and stored.

A hand-held anemometer (extech instruments an100-) were used to measure wind and temperature. It has a digital display and can measure by keeping the max-min values in its memory. It gives average values by making 20 measurements.

Pandas 0.23.0, the libraries of the Python 3.0 programming language, were used to evaluate the data, Matplotlib 2.2.2 and Seaborn 0.8.1 were used to draw the graphs of the data. Scipy 1.0.0 is used for statistical tests.

III. Results and Discussion

The designed system was operated at different pressures in the laboratory. In these conditions, the sealing of the system was observed and no problems were encountered. In addition to that, it was

confirmed that the paint mixture (as fertilizer) that the system received from the tank was given to the main pipeline at the desired rates. Then it was assembled in the hose reel irrigation system in the test area.

As stated in the method, filter papers are placed in the test area. The irrigation machine completed irrigation (100 m) in 68 minutes. In the experiments, the measurement groups were collected as 4 groups (4 repetitions) including 30 sample surfaces. These groups are named as A, B, C and D, respectively.

Descriptive statistics table of the values collected from the measurement surfaces are given in Table 1. The highest residue amount was obtained in group B with an average of 2.13 mg / cm2. Group A has the highest standard deviation with 0.68 mg / cm2 standard deviation. The median values of the measurement groups ranged from 0.50 mg / cm2 to 2.09 mg / cm2. Maximum residue amount was obtained from the B group with 3,48 mg / cm2. The coefficient of variation between the residue amounts on the filter papers varied between 21-38%.

The residual amounts obtained in the measurement groups can be seen in Fig. 3. Groups A, B and C show an intersecting distribution. It is seen that the D group has less residue than the other 3 groups. The reason for this is considered that the filter papers used in the D group are used on a sloping land.

TABLE 1. DESCRIPTIVE STATISTICS TABLE OF VALUES COLLECTED FROM MEASUREMENT SURFACES

(mg/cm2)	A	B	C	D
Number	30.000000	30.000000	30.000000	30.000000
Mean	1.783355	2.131660	1.709819	0.574196
Std.Dev	0.682431	0.626689	0.363178	0.429986
Min	0.330251	1.149273	1.030383	0.026420
25%	1.426684	1.694188	1.393659	0.254293
50%	1.750330	2.093791	1.803170	0.501982
75%	2.229194	2.513210	1.862616	0.713342
Max.	2.932629	3.487450	2.536328	1.730515

After analyzing the descriptive statistics values of the measurement groups, it was tried to express whether the residual values obtained in each measurement group showed normal distribution or not with histogram graphs (Fig 4). When histogram graphs of residue measurements were examined, results close to normal distribution were detected in the measurements taken in A, B and C groups. In the D group, although the results are close to the normal distribution, it was determined that the average value was collected towards the left of the axis.

The normality test of the measurement values was done using the D'Agostino and Pearson method [4, 5].For A, B, C and D measurement groups, 0.65, 0.53, 0.75 and 0.09 p-values were obtained,

respectively. Since all of these p-values obtained are greater than 0.05, these values are evaluated to have normal distribution.

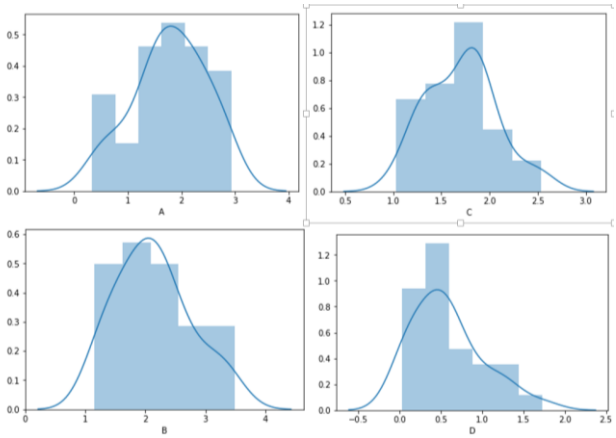

Fig. 3. Residual distribution histograms of measurement groups

After the normality test, whether there is a correlation between the measurement groups was examined by using Pearson correlation method. The results of the correlation test can be seen in Fig. 5. When the correlation values between the measurement groups were compared, the highest correlation (0.270) was found between the measurement groups B and D in a positive direction. The lowest correlation was found between 0.062 and A and B groups.

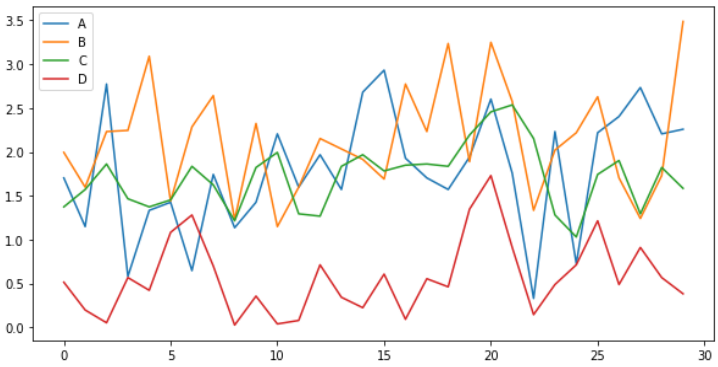

Fig. 4. Distribution of the amount of residue obtained in the measurement groups

Whether there is a statistically significant difference between the groups was analyzed using the Friedman Chi Square test. Analysis p-value was found to be 0.07. Since this value was greater than 0.05, the result of all measurement groups coming from the same distribution was evaluated.

Studies have shown that fertilization with irrigation is successful and necessary. Especially its success in drip irrigation systems has been shown by increasing efficiency and reducing chemical consumption [23, 24, 25]. This method is needed for applications with the hose reel irrigation machines.

IV. Conclusion

In field agriculture, sprinkler irrigation systems are used in plants such as cereals, but fertilization is not observed. Fertilization systems used in agriculture are mostly used in conjunction with the plants

planted, fruit trees and drip irrigation systems. For this reason, the development of a system that will reduce the excess water consumption in agricultural irrigation and give fertilizer disposal for the hose reel irrigation machines has been the subject of this study. For this purpose, a system including dosing pump, fertilizer tank and fittings has been designed. Then this system was examined in field and laboratory trials.

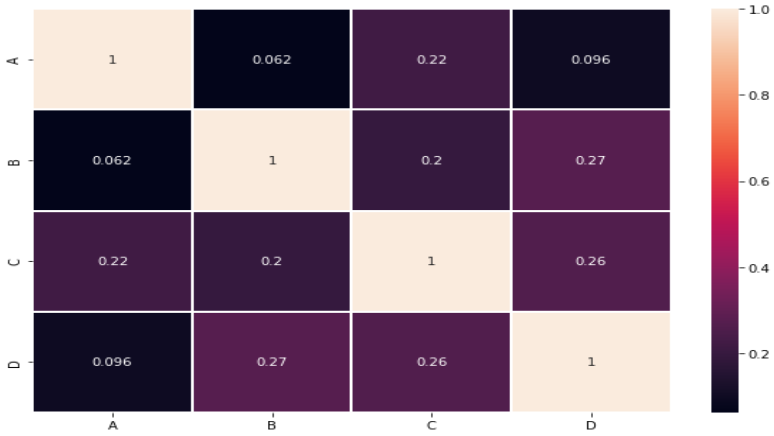

Fig. 5. Correlation values of measurement groups

According to the results obtained, the use of dosing pumps in drum irrigation systems gave positive results in order to increase irrigation water use and fertilization efficiency. The coefficient of variation for the homogeneous distribution varied between 21-38%. In this regard, fertilization efficiency and biological efficiency can be evaluated by using real fertilizer as the next step.

There is the potential to cause serious environmental problems, such as contaminating groundwater, when the chemical is not properly dosed and applied. A suitable system and components are needed for the effective and safe application of chemicals with water. This system generally consists of irrigation water pumping station, chemical injection pump, a storage unit for chemical, system calibration device, backflow preventing system and system safety equipment. For this purpose, a dosing system has been designed that can be used with the hose reel irrigation systems.

The hose reel irrigation machines, which are much more economical and useful compared to other irrigation methods in terms of economic life and usage cost, saving water in hot weather and are environmentally friendly. The hose reel irrigation machines, which can operate even at low pressures, have shown that they can prevent soil hardening and damage to crops with effective irrigation during agricultural production. Labor costs are low as irrigation can be done alone. Finally, it can be said that it also reduces field traffic. When the success of the system designed in this study is added to these benefits, the use of these machines will be more attractive for farmers.

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