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Effective Estimation of Total Failure Mode Effects and Analysis in Tea Industry

[1]M. Angeline Geetha and [2]R. Suresh Premil Kumar
[1]Department of Mechanical Engineering, Marthandam College of Engineering and Technology, Marthandam, India
[2]Stella Mary's College of Engineering, Aruthenganvilai, Kanyakumari District, Tamil Nadu, India

Abstract: The failure prevention is treated as one of the main enablers of achieving continuous quality improvement in Total Quality Management (TQM) projects. One of the risk-free beverages consumed by the humans is tea. In the study, a method of applying a technique known as the 'Total Failure Mode and Effects Analysis' (TFMEA) in tea industry is conceptually investigated. The TFMEA is unaccompanied by any complicated calculations and processes and hence it facilitates illiterate labor of the tea industry to participate in the endeavor of attaining the supreme goal of continuous quality enrichment in tea manufacturing. The underlying motivation of the investigation is to envisage a TFMEA in experimental scrutiny and soft computing technique called Feed Forward Back propagation Neural Network (FFBNN) which can effectively assist various training algorithms. The divergent failure mode contains several modules like the control mode, smoke mode, stewing mode and high fired mode in the tea industry so that the quantity of tea is assessed experimentally. The forecast procedure in the FFBNN is employed to predict the quantities of the tea in failure modes and three training algorithms are employed and the minimum error value of the quantity analyzing process is achieved in the Levenberg-Marquardt (LM) algorithm. From the cheering outcomes, the minimum error of all the failure modes in tea industry is 96.33% determined by the FFBNN process.

Key words: TQM, TFMEA, tea manufacturing, quality improvement, failure MODES, feed forward neural network

INTRODUCTION

In the modern manufacturing scenarios, flexibility is attaining zooming significance. A lot of investigation effort has been devoted to flexible manufacturing systems. A large majority of the studies address the issues of investment cost, flexibility measurement, inventory, scheduling and the tradeoffs between productivity and flexibility and so forth (Wang *et al.*, 2010). Inherent in the exploration of the manufacturing cycle time is a set of activities which range from defining the optimum production lot, calculating the quantity of needed parts, production preparation and launching, cycle scheduling, management of production activities with current asset engagement, to the analysis and investigations of material flow (Jovanovic *et al.*, 2014). The Manufacturing Execution System (MES) thus emerged as an enabling device for the manufacturing industries to capture data and extract knowledge in the form of decision (Banerjee *et al.*, 2013). A number of industries function productively for <50% of the functioning hours per year while several others have become moribund due principally to excessive downtime, supply failures for input resources and low spare capacity (Ohunakin and Leramo, 2012). In this regard, the Statistical Process Control (SPC) has surfaced as a novel system designed which is anchored in the Shewhart's conception of process variability which is extensively employed in the manufacturing procedures and the service functions for the quality sustainability purposes (Lim and Antony, 2014). Subsequently it is adapted to the Failure Mode and Effects Analysis technique (FMEA) to help the Safety Engineering in Medicine and Work supervise in controlling the perils of work accidents in a construction company (Patricio *et al.*, 2013). The FMEA represents a systematic bottom-up technique for recognizing potential critical failure modes of a manufacturing process or a product to furnish vital data for enrichment and risk appraisal (Haq *et al.*, 2015). The Production scheduling is very hard and time-consuming. In the dynamic, stochastic manufacturing scenarios, managers, production planners

Corresponding Author: M. Angeline Geetha, Department of Mechanical Engineering, Marthandam College of Engineering and Technology, Marthandam, India

and supervisors must not only produce high-quality schedules but also react quickly to unforeseen events and revise schedules in a cost-effective manner (Herrmann, 2006). The traditional quality management approaches, including the Statistical Quality Control (SQC), Zero Defects and Total Quality Management (TQM), have been key players for several years, while the Six Sigma has emerged as one of the most sophisticated continuous quality improvement initiatives to gain popularity and acceptance in a host of industries across the globe (Parsana and Desai, 2014). The FMEA represents a systematic technique for identifying and averting the incidence of potential failures in the product design, product and production process. The FMEA method was kick-started in the Aerospace Industries NASA some four decades back and still it has its influential sway (Jamshidi and Kazemzadeh, 2010).Nearly two-third of the world's population drink tea, second only to water in its consumption as a beverage. Tea is also a vital antioxidant agent which is deemed to avert an extensive gamut of ailments like cancer and heart diseases (Chen *et al*., 2006). Mean while, some researchers have advocated the deployment of advanced versions of the FMEA. Therefore, it becomes essential to explore the implementation of the FMEA and its advanced versions in tea industry (Ebenezer *et al*., 2011). The intent is to supply strong evidence for (not absolute proof of) the truth of the conclusion. It stems from experience with identical products and/or usage conditions. It is compared with deductive reasoning where a logically certain conclusion is reached from general statements (Kolich, 2014). The FMEA technique is effectively employed to resolve issues related to the manufacturing process. It starts with a process flow chart which illustrates each manufacturing step of a product. The potential failure modes at each work station are listed (Faisal *et al*., 2015). One of the most vital expenses which stem from any process is on account of the variability at any phase in the patient's care. Variability is generally related with contrasted with the clinical practice as no extra treatment was planned (Iannettoni *et al*., 2011). The small industrial units encompass industries with restricted scale of manufacturing functions, generate a single product or a few products with restricted levels of employment and investment and are a majority when compared to the large scale industries (Paunikar and Wankhede, 2014; Senthilmurugan and Perarasu, 2014). The procedure for conducting an FMEA is designed in three vital stages in which appropriate actions have to be defined. However, prior to the commencement of the FMEA method, it is essential to execute certain pre-work to substantiate that robustness and past history are included in the investigation (Ambekar *et al*., 2013).

Literature review: The production quality performance in the manufacturing systems processing worsening products was investigated by Colledani *et al*. (2015). They formulated a novel concept and technique to forecast the lead time distribution in multi-stage manufacturing systems with fly-by-night machines. Their innovative technique made it easy to optimally inventorying levels to attain the targeted production quality performance in the related mechanisms. The industrial merits were illustrated in an authentic manufacturing system generating the micro-catheters for the medical applications. In the long run, novel production control techniques to have a direct control on the lead time could be elucidated from the corresponding outcomes.

In 2014 Senthilmurugan and Perarasu (2014) significantly set up the Failure Mode Effects Analysis (FMEA) as one of the excellent devices for the reliability enrichment. The failure prevention was deemed as one of the vital catalysts for achieving incessant quality augmentation in industries. In fact, the theoreticians were propagating the employability of Failure Mode and Effects Analysis (FMEA) as the method for locating and correcting the failures in realizing the dream of nonstop quality expansion. Generally, in the related industries no Reliability and Total Quality Management (TQM) methods were employed. The unforeseen breakdowns and quality reduction in components and machineries of sugar industries were the vital issues faced in the absence of any appropriate TQM techniques.

The Failure Mode Effect Analysis and Total Productive Maintenance were smartly reviewed by Waghmare *et al*. (2014).The target of quality and reliability systems was the same-to achieve customer delight. The quality and reliability were identical. A system could not be reliable if it lacked superior quality. Similarly, a system could not be of high quality if it was non-reliable. The quality performance of a firm was habitually appraised by the dependability of the firm's equipment or machinery. If a system was found to be untrustworthy, it was erratic and if so, it would not be of superior quality. In this regard, the FMEA represented one of the most vital quality management approaches. The Total Productive Maintenance was a very advantageous method to perk up the productivity of plant and equipment with a modest investment in preservation.

In 2014 Naebulharam and Zhang (2014) remarkably launched the Manufacturing systems with perishable products which were extensively employed in practice such as the food, metal processing and so on. In the related systems, the quality of a part was greatly dependent on its residence time within the system. Particularly, they presumed that the probability that each unfinished segment was of superb quality was a decreasing function of its residence time in the previous buffer. Therefore, in the structure of serial production lines with machines having Bernoulli reliability model, they brilliantly brought in the closed-form formulas for performance appraisal in the two-machine line case and designed an aggregation-based process to approximate the performance measures in M > 2-machine lines. Moreover, they effectively explored the monotonicity attributes of these production lines by carrying out statistical tests. In accordance with these techniques, the monotonicity attributes of excellent part production rate, scrap rate and raw material consumption rate were investigated.

In 2014 Mahmud and Hilmi (2014) were instrumental in investigating the relevant issues in the association between the Total Quality Management (TQM) and SME performance. In their document, they deeply dealt with the imperative need for mediation in the association between the TQM and SMEs performance, viz the organization learning. Their theoretical concept was based on an overall evaluation of the pertinent literature prior to the design of several proposals relating to the practices of the TQM, organization learning and performance of the SMEs. Their document clearly anticipated that the TQM would support both organization learning and performance of SMEs.

In 2012 Krishnaraj *et al.* (2012) competently suggested the failure prevention as one of the major catalysts of achieving incessant quality enrichment. For the purpose, they utilized the Failure Mode and Effect Analysis (FMEA) approach to scale down the probability of system breakdown so as to realize fine product quality. Nevertheless, no strenuous endeavors have been found to be taken by the experimenters to steer clear of the drawbacks of the FMEA. The practical gap was overwhelmed by applying a method known as the Total Failure Mode and Effect Analysis (TFMEA). The relative investigation gap was revealed and investigated further by conducting literature review to draw synergy out of TFMEA along with the unconquered areas of the TFMEA where TFMEA could be performed.

MATERIALS AND METHODS

The objective of this proposed research is to develop the model for Tea manufacturing company utilized to the Total Failure Mode Effect and Analysis (TFMEA) Process with the FFBNN. Initially in this process the amount of green leaf is used to produce the perfect tea. If where is failure mode in manufacturing process the tea total quantity will be affected. The failure modes in the tea manufacturing process the steps considered in the Tea industry are identifying the failure mode and analyzing the quantity of the tea then predicting the quantity of the tea in FFBNN soft computing process. The need of the hour is that, this research and practical gap need to be filled by applying the techniques adopted in the TQM field in the manufacturing of tea. In the TFMEA process with FFBNN reduces the time period of the experimental analyzing process and also reduces the cost of the tea manufacturing process. In the FFBNN based on the artificial intelligence process different training algorithms are applied to predict the quantity of the tea in different category such as the control mode, smoke mode, stewing mode and high fired mode and the quantity is predicted in failure mode process. This analyzing process considers the input sources as the moisture content, time and temperature utilized to predict the quantity of the tea. In this network, the information moves in only one direction, forward, from the input nodes through the hidden nodes (if any) and to the output nodes. This analysis favors the study of applying the technique of the Total Failure Mode and Effect Analysis (TFMEA) in the tea industry. The block diagram of the proposed work is shown in Fig. 1.

Tea and its quality: Tea is habitually evaluated for its quality by professional tea tasters. The tasters base their judgment on their prior experience of tea from the producing area and their awareness of the regional conditions and preferences. Nevertheless, the paramount necessity for the chemical analysis crops up when there is a lingering doubt that the product has been adulterated or it illustrates certain qualities which are not different from the regular tea. Hence, the chemical quality constraints which reflect the intrinsic properties of the product are essential for the industry. The tea plants are propagated from seed or by cutting and it takes around 3 years before a new plant is ready for harvesting. Besides the warm zone, tea plants need a minimum of 127 cm (50 inches) of rainfall in a year and favor acidic soils. Many superior quality tea plants are cultivated at elevations of up to 1500 m. The plants grow gradually at these heights and attain a superior flavor. Left to grow wild, the tea plant expands into a tree many meters high, but kept to a height of roughly “24-36” by pruning for easy harvesting and superior yield.

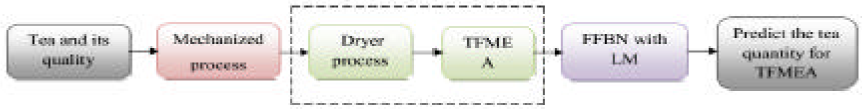

Fig. 1: Block Diagram for proposed method

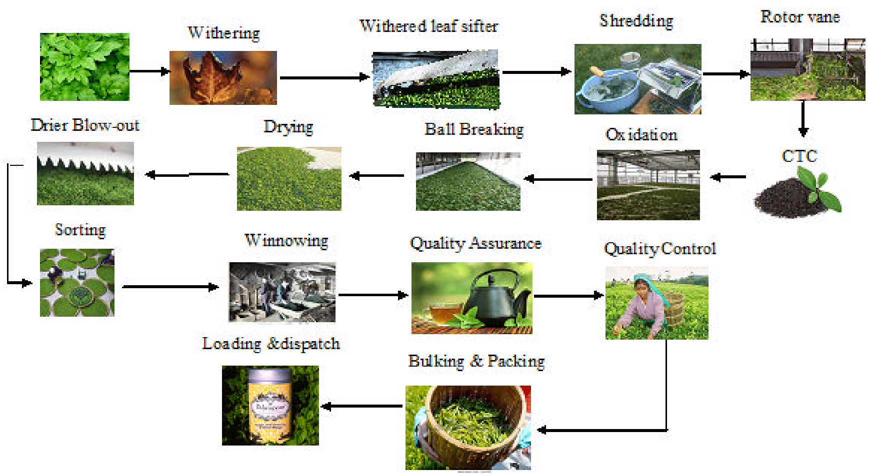

Fig. 2: Block diagram for tea industry

Mechanized process in tea industry: For the entire tea processing, good manufacturing practices are in vogue. A process flow chart which shows optimum situations integrating temperature and time for each activity is set up and performed. Relative humidity is watched and regulated to avert excessive moisture absorption in grading and packing. Potable water is employed for humidifiers to avert contagion. Figure 2 illustrates the manufacturing process of tea in industry.

Processing steps

Green leaf on arrival at factory: When the collection lorry arrive at the tea factory in the afternoon with the green leaf from the farmers. The temperature should not exceed 35°C. This process has no discoloration.

Withering: Fresh green leaf is made up of roughly 80% water and 20% dry matter. Uniform wither, elimination of surface moisture and concentration of polyphenols, without damaging the cells Moisture content 70-75 % in withering procedure.

Withered leaf sifter: The steady mechanized feed to the Rotor vane and consequently to the cutting rollers, elimination of grit, sand, small stones and other irrelevant matter.

Shredding: It decreases the volume of withered leaf. Rupture of leaf cells to facilitate polyphenols to blend freely with the enzyme Polyphone oxidizes while oxygen is available.

Rotor vane: Thorough mix of ruptured withered leaf with re-conditioning material. Effective pre-conditioning and the moisture content 55-58%. Temperature not to exceed 35°C.

CTC: Crush, tear and curl to achieve excellent appearance, density, dust grade recovery, bright infused leaf appearance with better liquoring properties. Dhool temperature level should not exceed 35°C and the Moisture content is also treated as 55-58 %.

Oxidation: Optimum ambient air supply to enable oxidation attain optimum ratio of the Thearubigin. Optimum loading temperature 27-30°C, Humidity level of the leaf is 85-95 %.

Ball breaking: Attain uniform standard of drying and obtain a higher recovery of dust grades which consist of under and over firing.

Drying: Drying is the mass transfer function consisting of removal of water from a solid, semi-solid or liquid and also removal of the moisture

Table 1: Total failure in control mode

Failure mode	Causes of failure	Effects of failure	Greenleaf processed	Fermentation	Made tea	Approved by
Control mode	Detection rating	Burnt taste of tea	20000 kgs	60 min	4700 Kgs	General manager

Table 2: Total failure in Smoke mode

Failure mode	Causes of failure	Effects of failure	Greenleaf processed	Withered leaf h^{-1}	Cutting output h^{-1}	Approved by
Smoke Mode	Not using smoke identifier	Burnt taste of tea	20000 kgs	1020 kgs	1700 kgs	General manager

to prevent case hardening, stewing process. Inlet temperature 130-140 deg. C. Moisture content 2.5-3.0%.

Drier blow-out: Re-fire if moisture goes beyond 6%. Separate the tea fibre to avert harshness, Preserved the permissible crude fibre content below 16.5 %.

Sorting: Elimination of long fiber/flaky teas in the fibrex machine, sorting process if grading the tea based on the sizes

Winnowing: Elimination of flaky grades to offer excellent appearance and density.

Quality assurance: Hourly tea tasting to avert taint, to preserve quality.

Quality control: Appearance, granularity, size, cleanliness and density.

- Infusion: Coppery Bright without cut leaf particles
- Liquor: Bright, Coloury, Strong and Brisk
- Liquor colour with milk: Bright amber with a pink tinge

Bulking and packing: Homogeneous mixing to avert change between bags to bag

Loading and dispatch: Inspection of the vehicles for any protruding nails bolts and nuts, wetness and foreign odor.

Process of dryer machine: A fluidized bed dryer (Kilburn Vibro Fluid Bed Dryer -KVD-A-1333) of BTRI is used for the test. It contains a heater system, a centrifugal type hot air blower, outlet hot air duct, a feed system, drive and excitation system, plenum chamber, drying chamber, exhaust and de-dusting systems and a cyclone system. The TFEMA analysis is carried in drying process.

Total failure modes in tea industry: The failure modes which are simple to perform are carried out initially and the difficult ones are taken up later. After the execution of each failure the financial merits and the efficacy of the implementation process have to be verified and if essential, the accomplishment process has to be rectified by the TFMEA team members. Of late, there have been intensive efforts in the tea industry to enhance the quality of tea to keep abreast of the developments in the competitive market. Even though TQM has been applied in various domains, it is conspicuously absent in the tea industry. TFMEA infuses totality in identifying, analyzing, rectifying and preventing the recurrence of failures. This facility of TFMEA also ensures that every failure is prevented from a total point of view of the entire organization. In Tea preparation process, important section is dryer. Most of the failures occur in drying process. The failure modes considered here

- Control mode
- Smoke mode
- Stewing mode
- High fired mode

Control mode: The dryers are endowed with a number of inputs which, if suitably regulated, may result in a cost-efficient product which is of satisfactory quality. The Dryer inputs are of two categories: those which can be manipulated like the valve, damper and burner settings, fan speeds and the belt feed rates and those which are not but which can greatly upset the components of the process.

Table 1 illustrates the total failure in dryer the part of control mode process, causes of failure based affecting the tea quality. Total green leaf treated as 20000 Kgs after the fermentation procedure the tea quality is 4700 Kgs.

Smoke mode: The Smoke taint is identified around 7.00 am and consequently the drier is stopped. The Smoke taint is detected and on inspection, it is noted that one of the tubes has developed a crack, through which, smoke has entered into the drier. This is checked by blocking both the ends of the tube. After establishing that there is no smoke, manufacturing is restarted. On account of the stopping of the drier, 510 Kg of fermented dhool has to be given up at about 850 kg of green leaf.

Table 2 shows the tea affected in smoke failure process. To avoid this problem in tea industry in the dryer, a smoke detector can be used. Due to smoke, manufacturing has to be stopped for 2h and after rectifying the defect, it resumed.

Table 3: Total failure in Stewing mode

Failure mode	Causes of failure	Effects of failure	Drier output h^{-1}	Drier retention time	Fuel	Approved by
Stewing mode	Over heating of tea	Burnt taste of tea	400 kgs	20 min	Firewood	General manager

Table 4: Total failure in High fired mode

Failure mode	Causes of failure	Effects of failure	Firewood consumption h^{-1}	Electricity units h^{-1}	Cost of manufacture	Approved By
High fired mode	Over heating of tea	Burnt taste of tea	500 kgs	400 units	Rs. 25/-	Generalmanager

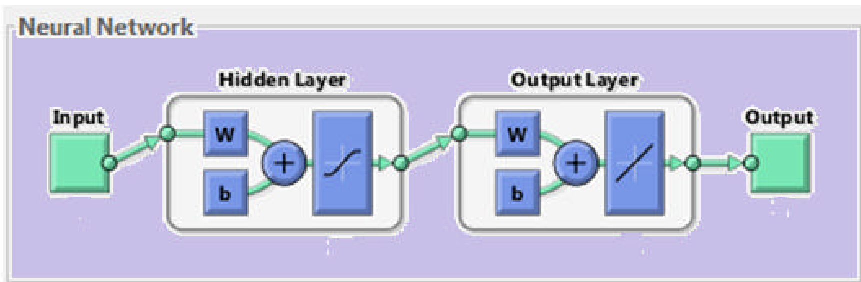

Fig. 3: Neural network structure

Stewing mode: Drying the tea too slowly leads to the stewing and drying it very quickly results the outside of the leaves drying much speeder than the inside, a situation which is known in tea production as case hardening. In fact, "an average loss of more than 4% moisture per minute results in bitterness and harshness in made tea. Moisture loss at 2.8-3.6% per minute is observed to generate tea with fine quality shown in Fig. 3 and Table 3.

Stewing happens on account of abrupt drop in ambient temperature and heavy rain. The wet firewood also causes lower inlet temperature. The control on rate of moisture elimination is (3.2-3.5 % per minute). Slow rate of moisture evaporation in preliminary phase of drying does not succeed in arresting oxidation early enough and allow it to continue at an accelerated par under conditions of high temperature and humidity giving rise to stewing.

High fired mode: The process heat can be generated by means of direct firing of fire wood. Fire wood available in nearby areas is appraised by multiplying area under wood cultivation and productivity per hectare, excessive inlet temperature and high exhausts temperature and the high retention time shown in Fig. 4 and Table 4.

In addition to having lower efficiency which results to high fuel consumption other recurring issues faced using air heater are such as the tube failure or leak, refractory arch falling and temperature variations. It leads to the over and under fired tea having a large impact on quality of made tea and market price realization for the manufacturing process.

Feed Forward Back Propagation Neural Network (FFBNN): The artificial neural network consists of a series of nodes (neurons) which have multiple connections with other nodes. Each connection has a weight associated with it which can be varied in strength, in analogy with the neurobiology synapses. The principle with which a neural network operates is relatively simple. Figure 3 shows the structure of FFBNN process which consists of three layers such as the input layer, hidden layer and output layer. Each of these neurons connects to every neuron in the next layer of neurons. In the feed forward neural network, back propagation algorithm is computationally effective and the adaptive techniques which make it very attractive in the dynamic nonlinear systems. This process considers input as the temperature and moisture content in Different failure modes such as the control mode, smoke mode, stewing mode and high fired mode then the output as the quantity of the tea.

Structure initialization: Initialization process three inputs based the input layer weight α_j and the hidden layer weights β_{ij} are initialized. Input I_i such as temperature, moisture content and time.

Input layer: The input layer contains a number of neurons. Above mention all input layer neurons are connected with the hidden layer. It has the two inputs and the input neurons are i_{1-3}. Input layer basic function equation which is defined as B_f is a Basic function of hidden neurons, 1 is a number of hidden units, β is a weight of the input layer neuron, N is a number of data and I is a input values. In these value based calculate the basics function:

$$B_f = \sum_{j=1}^{N} I_i \times \beta_{ij} \quad (1)$$

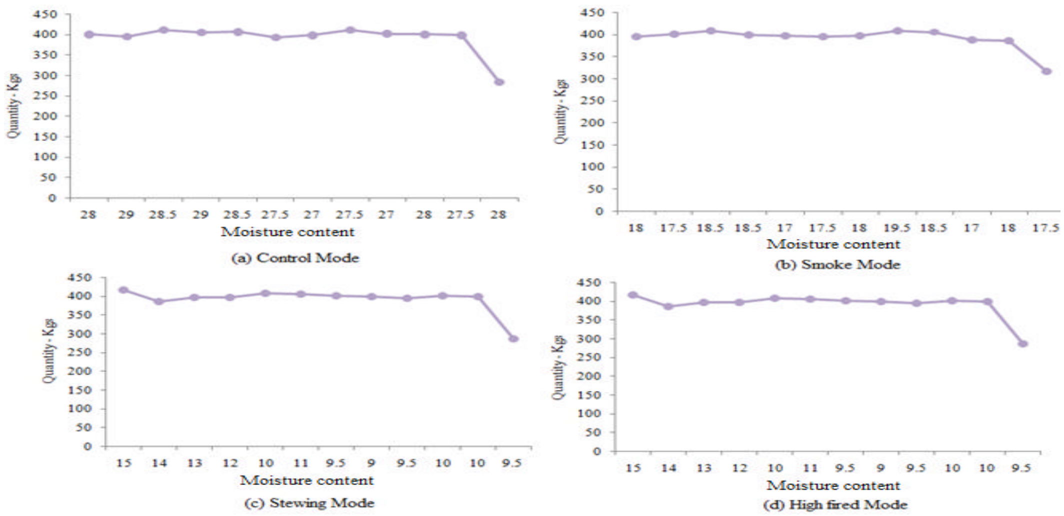

Fig. 4: Quantity of tea in different TFMEA

Where:

B_f = Is a basics function

β_{ij} = Is an input layer weight

i = is a number of input

Hidden layer: The hidden layer contains a number of neurons which are named as $h_1, h_2 \ldots h_n$. The hidden layers are connected with the output layer by using the neurons. The activation function is calculated by the following equation:

$$F_i = \sum_{j=1}^{h} \alpha_j \left(\frac{1}{1+\exp(-\sum_{i=1}^{N} I_i \beta_{ij})} \right) \quad (2)$$

Different training algorithm: In the ANN structure various training algorithms are employed to evaluate the minimum error value, in this process nine different training algorithms are used. Tea quantity prediction process employing different algorithm such as Levenberg-Marquardt (LM), BFGS Quasi-Newton (BFG) and Bayesian Regularization Back propagation (BR). In the ANN default structure these nine algorithms perform the process based on the hidden layer and neurons. Minimum error value is achieved in the Levenberg-Marquardt (LM) algorithm in the ANN default structure.

Levenberg-Marquardt (LM) algorithm: The Levenberg-Marquardt (LM) algorithm is the most widely used optimization algorithm. It outperforms the simple gradient descent and other conjugate gradient methods in a wide variety of problems. This document aims to provide an intuitive explanation for the algorithm. The LM algorithm is first shown to be a blend of gradient descent and Gauss-Newton iteration. Subsequently, another perspective on the algorithm is provided by considering it as a trust-regionmethod.Simple steepest descent method to minimize the following error function:

$$E = \sum_{t=1}^{l} (T_t - C_t) \quad (3)$$

Where:

T = The target,

C = The actual output for the t-th pattern of the neuron,

E = The error function,

l = The total number of training patterns

The weight update vector ∇N is calculated as:

$$\nabla N = [J^T(N)J(N) + \varepsilon I]^{-1} J^T(N)R \quad (4)$$

Below $J^T(w)$ J(w) is referred to as the Hessian matrix. Pertaining to μ = 0 the algorithm employs the Gauss-Newton approach. Pertaining to very large μ, the LM algorithm uses the steepest good or perhaps the error back propagation algorithm. The LM algorithm involves calculation on the Jacobian J (w) matrix at each and every iteration action as well as the inversion associated with JT (w) J (w) square matrix and the R is a vector of size.

Output layer: The output layer has a number of neurons. They are named as $v_1, v_2, \ldots v_n$. It has one output is quantity. The hidden layer neurons are connected with the output layer by the neurons. Each link has a weighted value such as α_1, α_2, ...α_n. The basis function of the Output units is expressed by the Equation:

$$O_l = \sum_{i=1}^{n} \alpha_i \sigma(F_i) \quad l = 1 \text{ and } i \in [1,....n] \tag{5}$$

Above mention ANN with training algorithm LM technique based predict the quantity of the tea in Kgs for different temperature and moisture content.

RESULTS AND DISCUSSION

The implementation process of TFMEA model at different failure modes is discussed in this section and also by using soft computing approach FFBNN with LM training algorithm. In order to aid this discussion the quantity of the tea is analyzed in fermentation dhool and dryer temperature. Soft computing approaches is implemented in the working platform of the MATLAB 2014 with the system configuration i5 processors with 4GB RAM.

Data set description: Here the datasets are considered in tea industry the real ti8me experiment conducted the data such as total tea quantity level, time , fermentated Dhool in different failure modes are collected to implement the FFBNN with tea industry process.

Experimental results of Total Failure Mode analysis: TFMEA process considers as different failure modes analysis the quantity of tea in fermentation dhool based on time in manufacturing industry.

Table 5-8 shows the Fermentated Dhool fed to drier in different failure modes and the quantity is analyzed. In all the failure modes in dryer the time based the quantity of tea is increasing. The data contains the annual facts of exports and production of tea (in kgs) of any region of India. If the time period is 5.10 the quantity of the tea is 1020 in high firing mode and similarly thousand counts of kilograms quantity is analyzed. The range is 1131-8324 μ gm L^{-1} steeping for 3 min and 1413-11449 μ gm L^{-1} steeping for 15min. Only 2 teas have levels above acceptable limits at 3 min of brewing but 6 of the teas have levels greater than the upper acceptable daily limit of 7000μgmL^{-1}. Clearly letting tea steep for longer than 3 min is not advisable. Two of the organic green teas have levels above 10,000 μ gm L^{-1} brewed for 15 min.

Figure 4 illustrates the quantity of the tea in failure mode process based on the moisture content, Moisture contents of tea are decided by taking samples from diverse locations of the long dryer bed. The average values of initial and final moisture contents of tea were found 50 and 3%, correspondingly. The moisture profile of tea along the bed of the fluidized bed is illustrated in Figure 4. The decreasing nature of moisture content at constant rate was observed to be within 2.5 min after that the drying rate is reduced exponentially. In Figure (a) moisture content percentage is 50% the quantity of the tea analyzed and when it is varied the quantity of the tea is reduced. Being a highly hygroscopic material, black tea collects the moisture from the atmosphere. Hence, care has to be taken to ensure that there is no surplus moisture in the tea before it is packed. In common, 3% moisture content is allowed.

Table 5: Fermentated Dhool fed to drier in control mode

Time	Quantity (Kgs)	Time	Quantity (kgs)
5.10	1020	11.10	1014
6.10	1015	12.10	1012
7.10	1018	13.10	1025
8.10	1022	14.10	1023
9.10	1025	15.10	1020
10.10	1020	16.10	1022

Table 6: Fermentated Dhool fed to drier in Smoke mode

Time	Quantity (kgs)	Time	Quantity(kgs)
5.10	1015	14.10	1020
6.10	1023	15.10	1017
7.10	508	16.10	1010
10.10	1010	17.10	1025
11.10	1035	18.10	1040
12.10	1030	19.10	330
13.10	1015	-	-

Table 7: Fermentated Dhool fed to drier in Stewing Mode

Time	Quantity (kgs)	Time	Quantity(kgs)
5.10	1005	11.10	1008
6.10	1025	12.10	1010
7.10	1029	13.10	1030
8.10	1014	14.10	1027
9.10	1019	15.10	1020
10.10	1037	16.10	1039

Table 8: Fermentated Dhool fed to drier in High fired mode

Time	Quantity (kgs)	Time	Quantity(kgs)
5.10	1020	11.10	1014
6.10	1015	12.10	1012
7.10	1018	13.10	1025
8.10	1022	14.10	1023
9.10	1025	15.10	1020
10.10	1020	16.10	1022

Soft computing technique FFBNN results: The FFBNN with diverse training algorithms is employed to predict the quantity of the tea in different TFMEA process. The following tables and figures illustrate the best training algorithm and error values of the FFBNN process in checking the quantity of tea in Control, stewing, smoke and high fired mode.

Figure 5 illustrates the error graph for failure modes with various training algorithm in FFBNN process and in

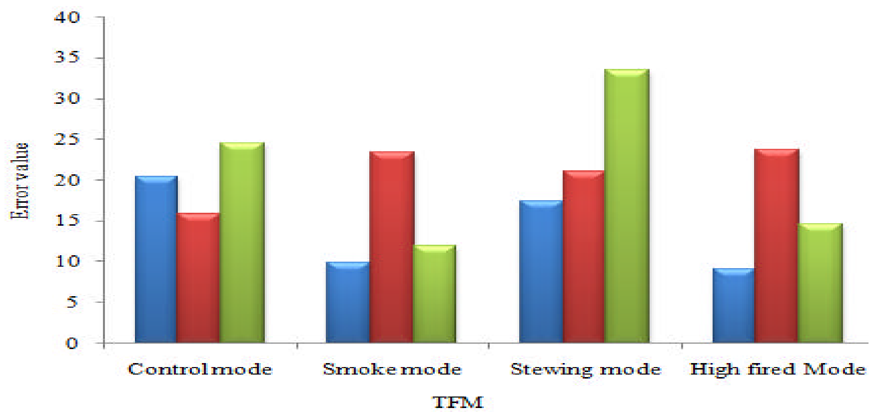

Fig. 5: Error graph for TFMEA

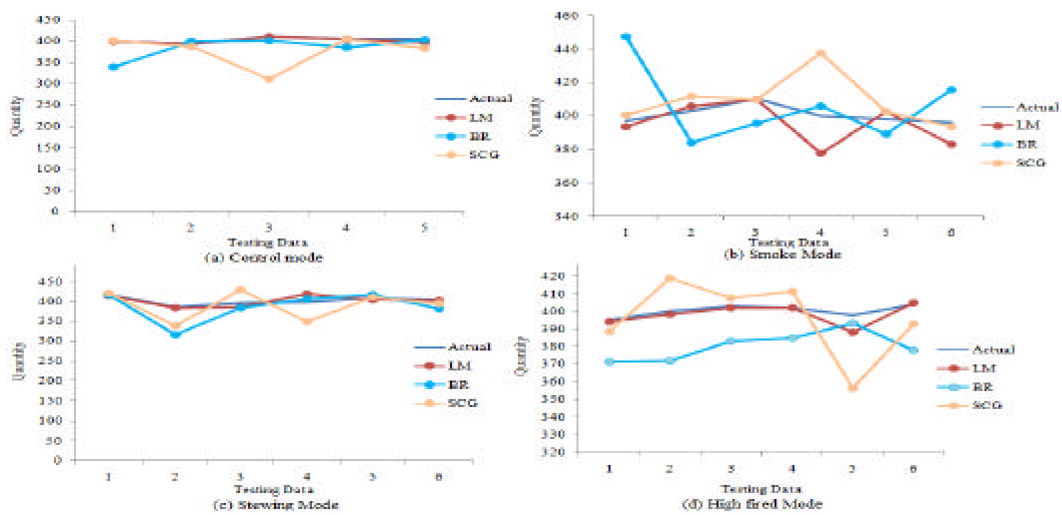

Fig. 6: Actual and predicted values for TFMEA

all the failure modes the minimum error value is achieved in the LM technique in relation to the other two algorithms such as Scaled Conjugate Gradient (SCG) and Bayesian Regularization (BR).The minimum value of smoke mode is 9.81 and compared to other two techniques the difference is 56.23%, the error minimization procedure based on the training algorithm process and activation function of the ANN process. In the Stewing mode BR algorithm the error value is 21.08 which is contrasted with the novel technique the error has minimized as 96.23%. There is identical values difference in all the failure mode quantity analysis procedures.

Above Fig. 6 illustrates the actual value of quantity of tea and predicted values in various algorithms. Figure 6(a) exhibits the tea quantity of control failure mode, the actual value is nearby value achieved in LM techniques. In the preliminary testing data the actual value is 400 and forecast value of innovative technique is 399. When, it is contrasted with the other two techniques the difference is 12.36%. Figure 6b-d exhibit the smoke, stewing and high fired mode failure operation all the failure mode analysis procedures the predicted value nearly equal to the actual value the difference of actual and predicted value is nearly equal to zero value in Total failure analysis procedure.

CONCLUSION

The tea industry has been contributing mammoth wealth to the societies in which it is powerful. The quantity of tea analysis process here scrutinizes the experimental process and the soft computing such as the FFBNN methods. A huge number of food technocrats have investigated on enhancing the production of tea and its quality. Probably the harshest criticism of the FMEA has been its restricted use in enhancing the designs. The quantity of tea creates the challenge of total failure modes. In this study four different failure modes are discussed. TFMEA furnishes an easy device to determine which risk has the supreme concern and therefore an action is necessary to avert an issue before it originates. During the soft computing process the minimum error of FFBNN with LM training algorithm of various modes like the control, smoke, stewing and high fired were 94.81, 97.5, 95.55 and 97.7% in the prediction process. In future FFBNN investigators will look towards further amazing enrichment methods for the achievement of diminished errors with their excellent techniques and also employing the Smoke detector in tea manufacturing industry.

REFERENCES

Ambekar, S.B., A. Edlabadkar and V. Shrouty, 2013. A review: Implementation of failure mode and effect analysis. Intl. J. Eng. Innovative Technol., 2: 37-41.

Banerjee, A., N. Bommu, P. Agarwal and N. Jaisankar, 2013. Design of manufacturing execution system for FMCG industries. J. Eng. Technol., 2013: 2366-2374.

Chen, Q., J. Zhao, H. Zhang and X. Wang, 2006. Feasibility study on qualitative and quantitative analysis in tea by near infrared spectroscopy with multivariate calibration. Analytica Chimica Acta, 572: 77-84.

Colledani, M., A. Horvath and A. Angius, 2015. Production quality performance in manufacturing systems processing deteriorating products. CIRP. Ann. Manuf. Technol., 64: 431-434.

Ebenezer, I.A., S.R. Devadasan, C.G. Sreenivasa and P. Iskanius, 2011. A literature view on the application of failure mode and effects analysis in tea industry. Intl. J. Value Chain Manage., 5: 251-264.

Faisal, K.P., H.K.F. Ummer, N.K.M. Ayaniyat, P. Nikesh and R. Jibi, 2015. Application of fmea method in a manufacturing organization focused on quality. J. Eng. Innovative Technol., 4: 64-70.

Haq, I.U., K. Izhar, S. Anwar, M.T. Khan, B. Ahmed and S. Maqsood, 2015. Fuzzy logic based failure mode and effect analysis of automotive powertrain assembly systems. J. Univ. Eng. Technol., 20: 57-64.

Herrmann, J.W., 2006. Improving production scheduling: Integrating organizational, decision-making, and problem-solving perspectives. IIE. Ann. Conf. Proc. Inst. Ind. Eng. Publisher, 2006: 1-6.

Iannettoni, M.D., W.R. Lynch, K.R. Parekh and K.A. McLaughlin, 2011. Kaizen method for esophagectomy patients: Improved quality control, outcomes and decreased costs. Ann. Thoracic Surgery, 91: 1011-1018.

Jamshidi, A. and R.B. Kazemzadeh, 2010. A fuzzy cost-based FMEA model. Intl. Conf. Ind. Experting Oper. Manage., 2010: 1-7.

Jovanovic, J.R., D.D. Milanovic and R.D. Djukic, 2014. Manufacturing cycle time analysis and scheduling to optimize its duration. Strojniski Vestnik J. Mech. Eng., 60: 512-524.

Kolich, M., 2014. Using failure mode and effects analysis to design a comfortable automotive driver seat. App. Ergon., 45: 1087-1096.

Krishnaraj, C., K.M. Mohanasundram, S.R. Devadasan and N.M. Sivaram, 2012. Total failure mode and effect analysis: A powerful technique for overcoming failures. Int. J. Productivity Qual. Manage., 10: 131-147.

Lim, S.A.H. and J. Antony, 2014. The implementation of statistical process control in the food industry: A systematic review. Proc. Intl. Conf. Eng. Oper. Manage., 2014: 1-9.

Mahmud, N. and M.F. Hilmi, 2014. TQM and Malaysian SMEs performance: The mediating roles of organization learning. Procedia Social Behav. Sci., 130: 216-225.

Naebulharam, R. and L. Zhang, 2014. Bernoulli serial lines with deteriorating product quality: Performance evaluation and system-theoretic properties. Intl. J. Prod. Res., 52: 1479-1494.

Ohunakin, O.S. and R.O. Leramo, 2012. Total productive maintenance implementation in a beverage industry: A case study. J. Eng. Applied Sci., 7: 128-133.

Parsana, T.S. and D.A. Desai, 2014. A review: Six sigma implementation practices in Indian manufacturing SMES. Intl. J. Eng. Res. Appl., 4: 663-673.

Patricio, R.P., R.E. Catai, C.R. Michaud and A. Nagalli, 2013. Model of risk management based in the FMEA technique-a case study in the construction of Gabions. Electron. J. Geotech. Eng., 18: 4183-4199.

Paunikar, A. and P. Wankhede, 2014. Process optimization and simulation of production industry. J. Adv. Res. Comput. Sci. Software Eng., 4: 618-629.

Senthilmurugan, P.R. and J.K. Perarasu, 2014. Modified Failure Mode and Effect Analysis (MFMEA) for machineries in sugar industry. Intl. J. Eng. Sci. Res. Technol., 1: 7051-7055.

Waghmare, S.N., D.N. Raut, S.K. Mahajan and S.S. Bhamare, 2014. Failure mode effect analysis and total productive maintenance: A review. Int. J. Innov. Res. Adv. Eng., 1: 183-203.

Wang, J., J. Li, J. Arinez, S. Biller and N. Huang, 2010. Quality analysis in flexible manufacturing systems with batch productions: Performance evaluation and nonmonotonic properties. IEEE. Trans. Autom. Sci. Eng., 7: 671-676.