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VALIDATION OF CRITICAL SUCCESS FACTORS OF CE USING FUZZY LOGIC TOOLBOX OF MATLAB

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Abstract- Concurrent Engineering (CE) is also known as simultaneous engineering. It has been seen as a systematic design and integrated product development approach, where product development has changed from traditional series design to production at the same time. Now a day's all manufacturers are trying to implement new methods, i.e., Multi Criteria Decision Making (MCDM) like Analytical Hierarchy Process (AHP), Piecewise-Affine (PWA), A Fuzzy-Based (FB) model, etc., along with CE drives to improve Business Performance. In this paper, an attempt has been made to show the synergistic suitability of CE Implementation for Indian SMEs. For the study, the most relevant factors affecting these drives like Supplier Involvement, Customer Involvement and Team Work has been considered and further these factors has been validated by the data given by experts in this fields using fuzzy logic toolbox of MATLAB which provides the steps for designing fuzzy inference systems using graphical tools.
Keywords: Concurrent Engineering, Fuzzy Logic (FL), Multi Criteria Decision Making (MCDM), Analytical Hierarchy Process (AHP), Fuzzy Inference System(FIS), MATLAB

1. INTRODUCTION (CE)

Today's commodity producers can use similar marketing ideas and approaches to reach the whole western world as demand has changed across borders. So, especially in developing countries, globalization is a great warning and a great opportunity. Industries and companies that previously owned a secure local market are facing new competitiveness from companies that never try to offer products in their parts of the world. Globalization has made universal competition for survival. However, global market ownership will be the most effective product award. To reduce the gap, SMEs have encouraged small and medium enterprises to create cutting-edge technologies to reduce the difference of INR 20 trillion to the Indian industry as well as the Indian economy. Concurrent Engineering (CE) is a manufacturing technology that supports SMEs in the development of India's economy. Nowadays, the organization does not have disability, processing, manufacturing, unnecessary waiting, loss of movement and surplus inventory (1). These factors are a challenge for organizations to find new tools and methods to move up the stairs in changing market scenarios. To overcome this problem and make it more efficient, many manufacturers used "Concurrent Engineering" (CE).

Concurrent Engineering is not immediately an issue of the company's problems and it is not only a way to improve engineering performance but it also emphasizes simultaneous consideration in the design stage and other aspects of the Product Life Cycle (PLC). It also supports the value of cooperation and confidence of the working group, the response to customer expectations by producing better, cost effective and much faster products, therefore, sharing and exchanging required knowledge and information in a manner that will improve decision making processes (2).

The organization should look to CE, who wishes to invest first and wait years for long-term profits and include the most important organizational and cultural exchanges. This is a profitable business strategy with significant corporate resources and its main goal is to improve product development performance.

2. LITERATURE REVIEW

This approach is chosen for this review is entirely literate. Selected articles from numerous editions published in journals during the last 22 years and thorough reviews. Moreover, analyzes and studies related to the management of capacity approaches and reviews in detail the impact of the use of CE from the effectiveness of the organization has been achieved.

Table 1 Research Studies

Research Study	Year	Factors
V.V. Ramana	2013	Customer needs Competitive position Product development cost
Sandip Basu, Nabarun Biswas,	2013	Development Cost

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Supriya Naha Biswas and Sweta Sarkar		Product reuse Design reuse Increase Efficiency Collaboration between departments
Ganagambegai	2012	Multifunctional team Training/Motivation Communication path Supplier involvement
Thankachan T. Pullan, M. Bhasi and G. Madhu	2010	Development time Improved quality Time to market Productivity Manufacturing cost
Baback Yazdani and Matthew Ainscough	2009	New product introduction Multifunctional teamwork Project management activities
A. Portioli-Staudacher	2008	Supplier involvement Role of management Corporate Culture Cross functional team Co-design Communication infrastructure Tools and techniques
Matthew Ainscough	2008	Project management Pilot study Self assessment tool Customer involvement

3. DESIGN OF STUDY

The survey has been carried out in various small-medium scale enterprises (SMEs) in the northern regions of India that have implemented CE. The research includes study of CE implementation towards the improvement of manufacturing performance. The inter-relationships of various factors of the study with manufacturing performance factors have been evaluated and validated by using various statistical tools.

3.1 OBJECTIVES OF THE STUDY

- To find out relationship between various input dimensions and performance parameters of the study.
- To find out critical success factors of CE.
- To validate critical success factors using Fuzzy Logic (FL) Toolbox of MATLAB.

3.2 Input Factors And Performance Measures Used In The Study

In order to identify the benefits of effective concurrent engineering approaches, it is imperative to implement multiple inputs and performance measures for implementation. In the current study, the seven main inputs (A, B, C, D, E, F and G) and the seven output indicators (i, ii, iii, iv, v, vi and vii) have been included in the implementation measures. Table 2 shows input factor and the performance measure used to evaluate the relationship between various CE issues.

Table 2 Input Factors and Performance Measures taken in the Study

Input Factors	Performance Measures
A-(Role of Top Management) B-(Training and Education) C-(Employee Empowerment) D-(Employee participation and rewards) E-(Supplier Involvement) F-(Team Work) G-(Customer Involvement)	i-(Strategic Business Performance) ii-(Product Quality Results) iii-(Productivity Improvement in Production Activities) iv-(Developmental Cost) v-(Timeliness of delivery) vi-(Lead Time) vii-(Employees Morale)

4. RESULTS

4.1 Test of Reliability and Validity of Factors

The Reliability of data is measured from factor loading and Cronbach's α has been framed using correlation analysis. Cronbach's α is most commonly used psychometric measures in accessing survey instruments and scales (3). Cronbach's α for all the variables should be significantly greater than 0.65 regarding for validating the reliability of data for various categories. Cronbach's α is the basic formula for determining the reliability based on internal consistency. Therefore, the Cronbach's α a for various categories, that is, implementation dimensions or input parameters (independent variables) and performance parameters (dependent variables) of a constructed questionnaire have been evaluated to ascertain the reliability of the input and output data collected through the "CE questionnaire". The Table 3 shows values of Cronbach's α for various success factor and performance measures.

Table 3 Input Factors and Performance Measures

Input Factor	Cronbach α value	Performance Measures	Cronbach α value
A	0.714	i	0.767
B	0.729	ii	0.736
C	0.866	iii	0.680
D	0.764	iv	0.726
E	0.720	v	0.662
F	0.823	vi	0.680
G	0.800	vii	0.719

From Table 3, it is clear that the values of Cronbach's α for all the input and performance measures is greater than 0.65. This indicates the significantly high reliability of data for various input and output factors.
Discriminate Validity Analysis has been used for the validation of all the input variables (A, B, C, D, E, F and G) and output variables (i, ii, iii, iv, v, vi and vii). It is clear from the Table 4 that all the respective Covariance values with-in the group are more than the value of covariance outside the group.

Table 4 Covariance Values for Input and Performance Measures

	A	B	C	D	E	F	G	i	ii	iii	iv	v	vi	vii
A	.004	.001	.000	.001	.004	.001	.004	.004	.001	.001	.002	.002	.003	.001
B	.001	.006	.003	.002	.001	.003	.001	.000	.002	.001	.004	.000	.001	.002
C	.000	.003	.012	.004	.000	.002	.001	.001	.005	.001	.003	.002	.001	.007
D	.001	.002	.004	.007	.001	.002	.001	.001	.007	.001	.002	.000	.000	.005
E	.004	.001	.000	.001	.007	.002	.005	.007	.000	.001	.001	.000	.005	.001
F	.001	.003	.002	.002	.002	.011	.003	.001	.002	.001	.005	.001	.002	.001
G	.004	.001	.001	.001	.005	.003	.009	.005	.001	.002	.002	.002	.004	.001
i	.004	.000	.001	.001	.007	.001	.005	.007	.001	.001	.000	.001	.005	.001
ii	.001	.002	.005	.007	.000	.002	.001	.001	.008	.000	.003	.000	.000	.004
iii	.001	.001	.001	.001	.001	.001	.002	.001	.000	.004	.001	.004	.000	.001
iv	.002	.004	.003	.002	.001	.005	.002	.000	.003	.001	.008	.001	.000	.001
v	.002	.000	.002	.000	.000	.001	.002	.001	.000	.004	.001	.008	.001	.001
vi	.003	.001	.001	.000	.005	.002	.004	.005	.000	.000	.000	.001	.008	.002
vii	.001	.002	.007	.005	.001	.001	.001	.001	.004	.001	.001	.001	.002	.015

4.2 Relationship between Various Input Dimensions and Performance Parameters of the Study
The IBM SPSS and Microsoft Excel software are used to carry out statistical analysis.
The notations used and their meanings are given below:
p - Level of significance;
r - Pearson correlation coefficient;
β - Regression coefficient (β coefficient); and
R - Multiple correlation coefficient
The Pearson product-moment correlation coefficient is a measure of the strength of the linear relationship between two variables. It is referred to as Pearson's correlation or simply as the correlation coefficient. ... A perfect positive linear relationship, r = 1. The Pearson's Correlation coefficient 'r' between input factors and performance measures has been counted for the determination of contributions of specific input factor towards realization of various performance measures are shown in Table 5.

Table 5 Values of Pearson's Correlation for all Input Factors and Performance Measures of TQM organizations

	i	ii	iii	iv	v	vi	vii

A	.659**	.195	.268	.264	.331*	.550**	.079
p-value	.000	.223	.090	.095	.035	.000	.623
N	41	41	41	41	41	41	41
B	.057	.250	.160	.541**	-.009	.103	.208
p-value	.724	.115	.318	.000	.953	.523	.191
N	41	41	41	41	41	41	41
C	.056	.476**	.119	.349*	.207	.055	.496**
p-value	.726	.002	.459	.025	.193	.734	.001
N	41	41	41	41	41	41	41
D	.121	.951**	-.121	.335*	.007	.006	.501**
p-value	.450	.000	.450	.032	.963	.969	.001
N	41	41	41	41	41	41	41
E	.976**	.052	.157	.080	.066	.675**	.062
p-value	.000	.749	.327	.617	.682	.000	.698
N	41	41	41	41	41	41	41
F	.123	.171	.104	.563**	.150	.243	.040
p-value	.442	.286	.518	.000	.348	.126	.805
N	41	41	41	41	41	41	41
G	.648**	.172	.271	.250	.277	.473**	.073
p-value	.000	.283	.087	.114	.080	.002	.651
N	41	41	41	41	41	41	41

**Correlation is significant at the 0.01 level (two-tailed)

*Correlation is significant at the 0.05 level (two-tailed)

The Table 5 indicates that there is a Strong Correlation of A-Role of Top Management issues with (i)-Business Performance (0.659**), B-Training and Education issues with (iv)-Development Cost (0.541**), C-Employee Empowerment issues with (vii)-Employees Morale (0.496**), D-Employee Participation and Rewards issues with (ii)-Product Quality (0.951**), E-Supplier Involvement issues with (i)–Business Performance (0.976**), F-Team Work issues with (iv)-development Cost (0.563**) and G-Customer Involvement issues with (i)-Business Performance (0.648**).

In order to know about Critical Success Factors for attaining results through CE implementation, the significant correlations has been obtained as a result of Pearson's Correlation and Covariance and these are validated through 'Multiple Regression Analysis' as shown in Table 6.

Table 6 Multiple Regressions among CE Implementation Input Factors and Performance Measures

Performance Measures	Input factors	Beta value β	t-value	Significance (p-value)	R/R²-value	F-value
i	B	0.083	2.404	0.022	0.985/0.969	148.559
	E	0.915	21.386	0.000		
ii	G	0.920	14.748	0.000	0.955/0.912	49.126
iii	F	0.390	2.205	0.035	0.530/0.281	1.839
iv	B	0.326	2.404	0.022	0.729/0.531	5.345
	C	.410	3.095	0.004		
v	F	0.367	2.014	0.052	0.484/0.235	1.445
vi	E	0.560	3.256	0.003	0.709/0.502	4.757
vii	F	0.275	1.704	0.098	0.630/0.397	3.105
	G	0.408	2.492	0.018		

Table 7 Critical Success factors obtained from Multiple Regression Analysis of CE Organizations

Performance Measure	Success factors
i	B,E
ii	G
iii	F
iv	B
v	F
vi	E

vii	F,G

4.3 Validation of Critical Success Factors Using Fuzzy Logic Toolbox of MATLAB

The Fuzzy Logic (FL) set theory was introduced by (5). The principle of Fuzzy logic theory was established on the basis of private ownership of representing human representation and uncertainty, to take the path of real world knowledge. The mathematical approach to assign each possible value individually in the universe of discourse, the set of fuzzy logic corresponds to the degree which is well-suited with their concepts of its logic. (source:ebook:Rajasekran and Vijaylakshami Pai: ANN and AI and Fuzzy System).

The fuzzy set is based on its Membership function (MF) and MF describes the information. MF must really satisfy that it must vary between 0 and 1 because MF is based on the membership value in range. According to definition MF is the curve, of each point in the input space mapped to a membership value in range [0 1]. The result can be optimized by defining the true relationship between input and the output variables, where input and output of a system or process also having a mathematical relationship of a given function. The MATLAB is a tool of Fuzzy Logic to refine and ruled the fuzzy sets and evaluate its rules of the function.

4.3.1 Fuzzy Inference System

The Fuzzy Inference System is a methodology based on fuzzy theories that reflect the value of the resulting value. The mechanism of mapping is based on a set of rules (6). The manufacturing system has been successfully implemented in areas such as computer vision, automatic control, decision analysis, data classification and expert systems. The Mamdani and Sugeno are the two types of interference system. Mamdani's fuzzy inference method was proposed in 1975 by Ebrahim Mamdani as an attempt to control a steam engine and boiler combination by synthesizing a set of linguistic control rules obtained from experienced human operators is the most commonly seen fuzzy methodology.

4.3.2 Fuzzification of CE

Fuzzy logic system with inputs and output being fuzzified using appropriate MFs. The inputs to FL are success factors Training and Education (T&E), Supplier Involvement (S.I), Team Work (T.W) and Customer Involvement (C.I). The output is the result whose value shows whether to accept, under consider or reject the selection of concurrent engineering. The data has been collected by consulting various representatives of specific industries. The representative of industries provides information regards to current issues they were facing and their solution in quantitative way. The data has been taken out at the each level of organization The following sections narrate each component of the system as shown in Figure 1 which depicts the empirical transfer function of LM-GM from Equation 1

Suitable CE method = f [T&E, S.I, T.W and C.I] Eq. 1

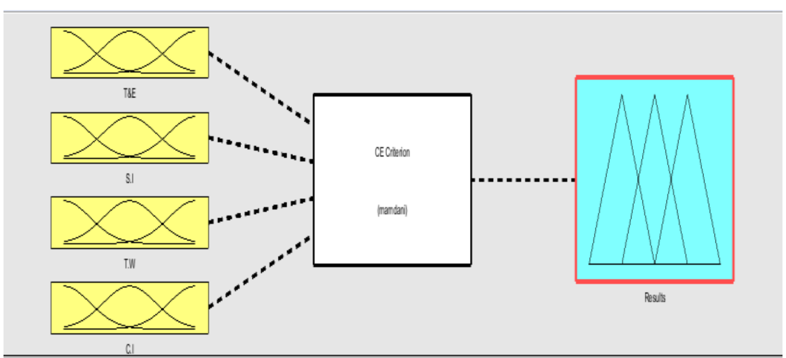

Fig. 1 Empherical Transfer Function of CE Approach

4.3.3 Setup Membership Function of Training and Education Issues

The analysis of the different issues associated with it reveals that most organizations generally conduct training and educational programs to update employee skilled and also gives training & education to the employees to implement CE in an organization has to consider these factors. The fuzzy set rules defines if the training and education issue less or more than -7 to 7% of required value than system is considered accepted or rejected if the training and education issue lies between 5 to 7% it is considerably very high or very low. If the value lies between 3 to 5% it is considerable high or considerable low. If the training and education issue varies between -3 to 3% than it is optimized. The range of training and education issue in fuzzy format is shown in Table 8 and the Membership transfer function in fuzzy format of training and education issue in Figure 2.

Table 8 Range for Training and Education Measurements

S.No.	Linguistic Term	Range
1	Reject	More than -7%

2	Very Low	-7% to -5%
3	Considerable Low	-5% to -3%
4	Optimum	-3% to +3%
5	Considerable High	+3% to +5%
6	Very High	+5% to +7%
7	Accept	More than +7%

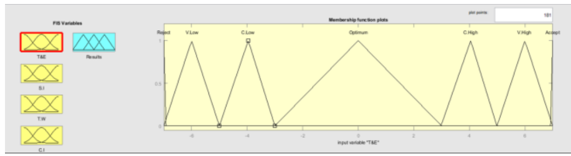

Figure 2 The Membership Transfer Function in Fuzzy Format of Training and Education Issue

4.3.4 Setup Membership Function of Supplier Involvement

The fuzzy set rules defines if the Supplier Involvement issue less or more than -10 to 10% of required value than system is considered accepted or rejected if the Supplier Involvement issue lies between 8 to 10% it is considerably very high or very low. If the value lies between 6 to 8% it is considerable high or considerable low. If the Supplier Involvement issue varies between -6 to 6% than it is optimized. The range of Supplier Involvement issue in fuzzy format is shown in Table 9. The Membership transfer function in fuzzy format of Supplier Involvement issue in Figure 3.

Table 9 Range for Supplier Involvement measurements

S.No.	Linguistic Term	Range
1	Reject	More than -10%
2	Very Low	-10% to -8%
3	Considerable Low	-8% to -6%
4	Optimum	-6% to +6%
5	Considerable High	+6% to +8%
6	Very High	+8% to +10%
7	Accept	More than +10%

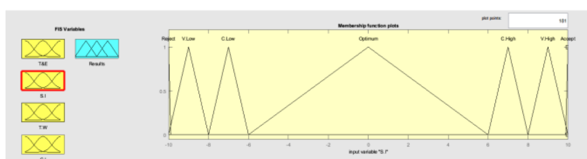

Fig. 3 Membership Transfer Function in Fuzzy Format of Supplier Involvement

4.3.5 Setup membership function of Team Work

The fuzzy set rules defines if the Team Work issue less or more than -5 to 5% of required value than system is considered accepted or rejected if the Team Work issue lies between 3 to 5% it is considerably very high or very low. If the value lies between 1 to 3% it is considerable high or considerable low. If the Team Work issue varies between -1 to 1% than it is optimized. The range of Team Work issue in fuzzy format is shown in Table 10 and the Membership transfer function in fuzzy format of Team Work issue in Figure 4.

Table 10 Range for Team Work measurements

S.No.	Linguistic Term	Range
1	Reject	More than -5%
2	Very Low	-5% to -3%
3	Considerable Low	-3% to -1%
4	Optimum	-1% to +1%
5	Considerable High	+1% to +3%
6	Very High	+3% to +5%
7	Accept	More than +5%

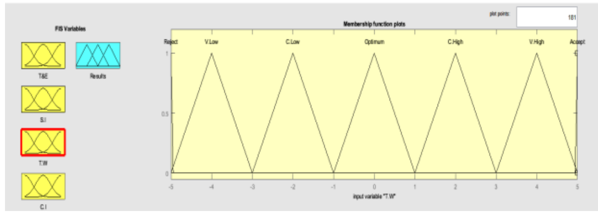

Fig. 4 Membership Transfer Function of Team Work in Fuzzy Format

4.3.6 Setup Membership Function of Customer Involvement

The fuzzy set rules defines if the Customer Involvement issue less or more than -8 to 8% of required value than system is considered accepted or rejected, if the Customer Involvement issue lies between 6 to 8% it is considerably very high or very low. If the value lies between 4 to 6% it is considerable high or considerable low. If the Customer Involvement issue varies between -4 to 4% than it is optimized. The range of Customer Involvement issue in fuzzy format is shown in Table 11 and the Membership transfer function in fuzzy format of Customer Involvement in Figure 5.

Table 11 Range for Customer Involvement measurements

S.No.	Linguistic Term	Range
1	Reject	More than -8%
2	Very Low	-8% to -6%
3	Considerable Low	-6% to -4%
4	Optimum	-4% to +4%
5	Considerable High	+4% to +6%
6	Very High	+6% to +8%
7	Accept	More than +8%

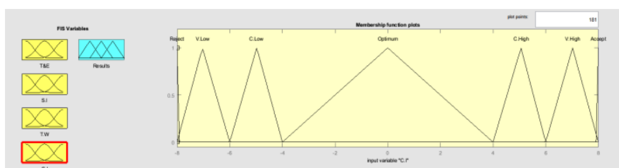

Fig. 5 The membership Transfer Function of Customer Involvement in Fuzzy Format

4.3.7 Results Checking the Suitability of CE Approach

As discussed earlier, again the result is to decide whether to select the concurrent engineering is effective approach or not. If the result value lies between 0 to 3, it is considered as rejected approach, between 3 to 6 is considered as poor (Under Consideration) and between 6 to 8 is considered as acceptable approach and between 8–10 as Optimum approach is shown in Table 12. The transfer function of results in fuzzy format is shown in Figure 6. The gaussmf curve is asymmetrical with two sided gaussian curve is used to represents the membership functions of results. The result has advantage to represent smooth and non-zero outputs at all points.

Table 12 Range for LM-GM result measurement (Source: Singh and Ahuja, 2013)

Fuzzy	Linguistic Term	Range
1	Reject	0-3
2	Under Consideration	3-6
3	Acceptable	6-8
4	Optimum	8-10

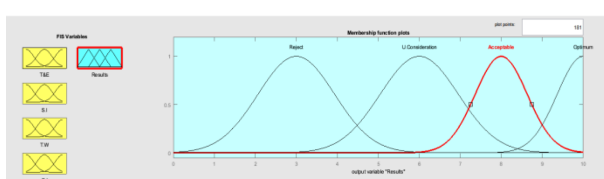

Fig. 6 Transfer Membership Function of Results in Fuzzy Format

4.3.8 Fuzzy evaluation and rules and solution

The following Tables 13, 14, 15, 16, 17, 18, 19, 20 and 21 shows the formation of fuzzy rules. There are 225 rules following the format ‘if (condition a) and (condition b) and (condition c) and (condition d) than (result c)’ corresponding to the combination of input conditions. These if-than rule statements are used to formulate the conditional statements that comprise FL in case of CE approach.

Table 13 Demonstrating fuzzy rules for CE result when 'Supplier Involvement' is Very High and 'Customer Involvement' is Very Low

TE / T.W	V.Low	C.Low	Optimum	C.High	V.High
V.Low	Reject	Reject	Reject	Reject	Reject
C.Low	Reject	Reject	Reject	Reject	Reject
Optimum	Reject	Reject	Accept	Accept	Accept
C.High	Reject	Reject	Accept	Accept	Accept
V.High	Reject	Reject	Accept	Accept	Accept

Table 14 Demonstrating fuzzy rules for CE result when 'Supplier Involvement' is Very Low and 'Customer Involvement' is Very High

TE / T.W	V.Low	C.Low	Optimum	C.High	V.High
V.Low	Reject	Reject	Reject	Reject	Reject
C.Low	Reject	Reject	Reject	Reject	Accept
Optimum	Reject	Reject	Accept	Accept	Accept
C.High	Reject	Reject	Accept	Accept	Accept
V.High	Reject	Accept	Accept	Accept	Accept

Table 15 Demonstrating fuzzy rules for CE result when 'Supplier Involvement' is Optimum and 'Customer Involvement' is Optimum

TE / T.W	V.Low	C.Low	Optimum	C.High	V.High
V.Low	Reject	Reject	Reject	Reject	Reject
C.Low	Reject	Reject	Accept	Accept	Accept
Optimum	Reject	Accept	Accept	Accept	Accept
C.High	Reject	Accept	Accept	Accept	Accept
V.High	Reject	Accept	Accept	Accept	Accept

Table 16 Demonstrating fuzzy rules for CE result when 'Supplier Involvement' is Very Low and 'Customer Involvement' is Very Low

TE / T.W	V.Low	C.Low	Optimum	C.High	V.High
V.Low	Reject	Reject	Reject	Reject	Reject
C.Low	Reject	Reject	Reject	Reject	Reject
Optimum	Reject	Reject	Reject	Reject	Reject
C.High	Reject	Reject	Reject	Reject	Accept
V.High	Reject	Reject	Accept	Accept	Accept

Table 17 Demonstrating fuzzy rules for CE result when 'Supplier Involvement' is Very High and 'Customer Involvement' is Very High

TE / T.W	V.Low	C.Low	Optimum	C.High	V.High
V.Low	Reject	Reject	Accept	Accept	Accept
C.Low	Reject	Reject	Accept	Accept	Accept
Optimum	Reject	Accept	Accept	Accept	Accept
C.High	Reject	Accept	Accept	Accept	Accept
V.High	Reject	Accept	Accept	Accept	Accept

Table 18 Demonstrating fuzzy rules for CE result when 'Supplier Involvement' is Optimum and 'Customer Involvement' is Very High

TE / T.W	V.Low	C.Low	Optimum	C.High	V.High
V.Low	Reject	Reject	Reject	Reject	Accept
C.Low	Reject	Reject	Accept	Accept	Accept
Optimum	Reject	Accept	Accept	Accept	Accept
C.High	Reject	Accept	Accept	Accept	Accept
V.High	Reject	Accept	Accept	Accept	Accept

Table 19 Demonstrating fuzzy rules for CE result when 'Supplier Involvement' is Very High and 'Customer Involvement' is Optimum

TE / T.W	V.Low	C.Low	Optimum	C.High	V.High
V.Low	Reject	Reject	Reject	Reject	Accept
C.Low	Reject	Reject	Accept	Accept	Accept
Optimum	Reject	Accept	Accept	Accept	Accept
C.High	Reject	Accept	Accept	Accept	Accept
V.High	Reject	Accept	Accept	Accept	Accept

Table 20 Demonstrating fuzzy rules for CE result when 'Supplier Involvement' is Very Low and 'Customer Involvement' is Optimum

TE / T.W	V.Low	C.Low	Optimum	C.High	V.High
V.Low	Reject	Reject	Reject	Reject	Reject
C.Low	Reject	Reject	Reject	Reject	Accept
Optimum	Reject	Reject	Accept	Accept	Accept
C.High	Reject	Reject	Accept	Accept	Accept
V.High	Reject	Accept	Accept	Accept	Accept

Table 21 Demonstrating Fuzzy Rules for CE Result When 'Supplier Involvement' is Optimum and 'Customer Involvement' is Very Low

TE / T.W	V.Low	C.Low	Optimum	C.High	V.High
V.Low	Reject	Reject	Reject	Reject	Reject
C.Low	Reject	Reject	Reject	Reject	Accept
Optimum	Reject	Reject	Accept	Accept	Accept
C.High	Reject	Reject	Accept	Accept	Accept
V.High	Reject	Accept	Accept	Accept	Accept

A continuum of fuzzy solutions for equation (1) is presented in Figure 7 using the rule viewer of fuzzy toolbox of MATLAB, there are four inputs success factors, i.e., Supplier Involvement (S.I), Training and Education (T&E), Team Work (T.W) and Customer Involvement (C.I) can be set within the upper and lower specification limits and the output response is calculated as a score that can be translated into linguistic terms. In this instance if the value of Supplier Involvement is entered 1.44 (optimal value), Training and Education 2.44 (optimal value), Team Work 0.621 and Customer Involvement 1.55 (optimum value) the order output in Figure 8 is coming as of 8 which specifies the system is 'Optimum' linguistically.

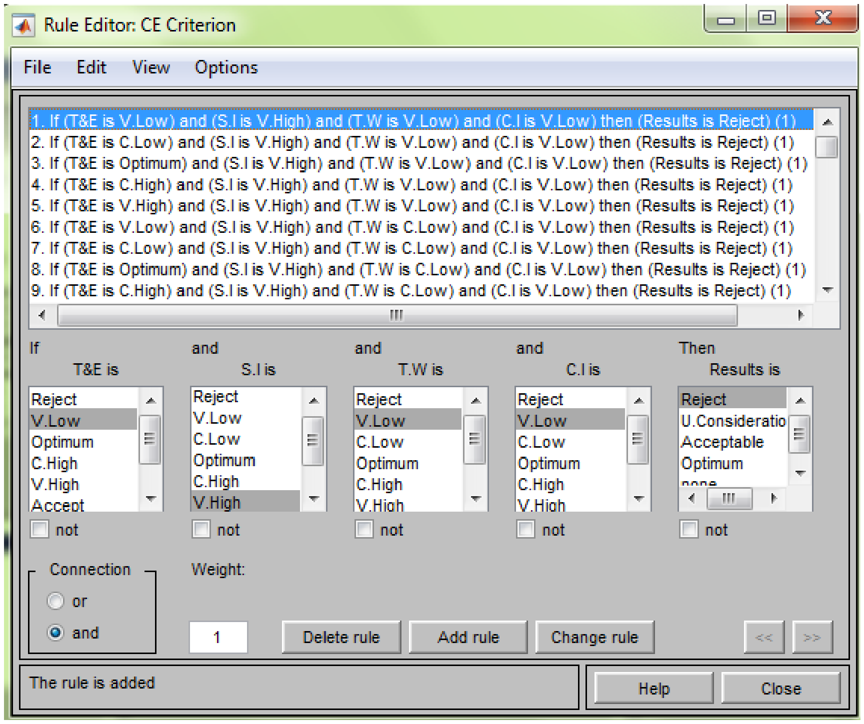

Fig. 7 Fuzzy Set Rules for CE

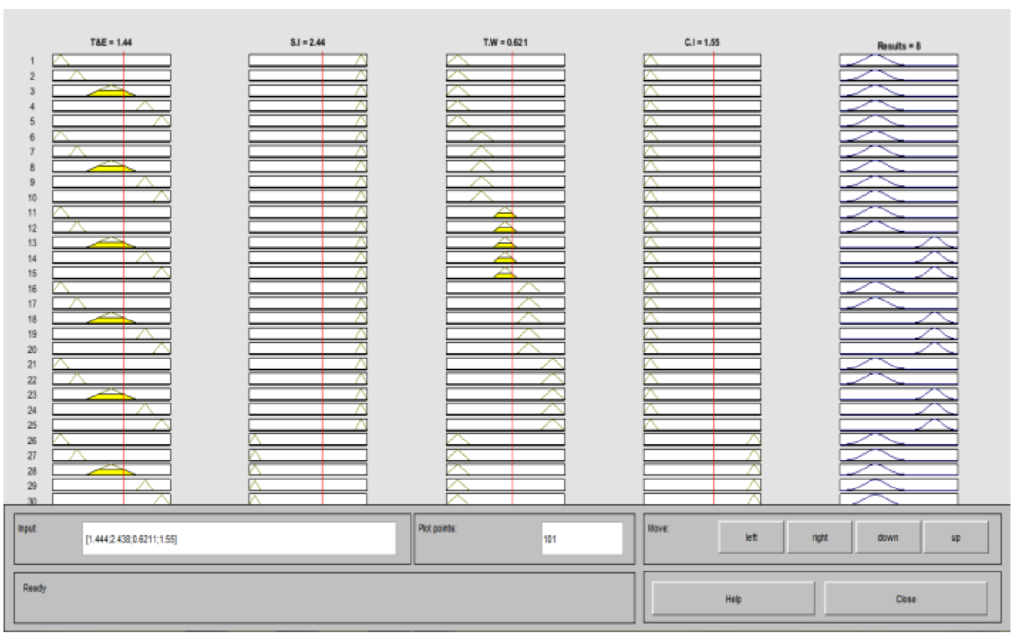

Fig. 8 Continuous Fuzzy Solutions for CE Results

5. CONCLUSION

CE approaches is considered to be technique and tool needed for the planning, implementation and control of the quality. The objective of system is to achieve the synergy and to improve the business performance excellence in the context of manufacturing organization. CE focuses on principles towards achieving the customer satisfaction and continuous improvements, and can get a strong change in productivity (measured by cost, timeliness, service, and quality).This approach is generated in developed countries and have different orientations. Therefore, in this study an assessment of the SMEs has been done based on CE approach using fuzzy logic toolbox of MATLAB. Most important factors under CE, i.e., Supplier issue, customer involvement and team work has been considered as MFs for fuzzy input as discussed by experts in this field and CE coordinators from various manufacturing organizations. Also, there expert opinion has been taken to formulate the fuzzy ‘if then’ rules. Lastly, FIS has been formed for CE approach and the fuzzification process of CE approach has been performed during run time by assigning appropriate MFs to the required approaches. The result shows that there are various critical success factors that helps to successful implement CE in manufacturing industries and this has been shown with the help of fuzzy rule viewer and also to analyses the performance of fuzzy system.

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