CUSTOMER PREFERENCE AND PRODUCT CONFIGURATION THROUGH DESIGN AND IMPLEMENTATION OF FUZZY DEMATEL AND TOPSIS APPROACH IN MULTI CLEAN INDUSTRIES IN INDIAN MILIEU

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ABSTRACT

In modern days customer criticism quickly changing to market fragment, channel of variant product design are diagnosed to reduce lead time significantly. A manufacturing industries habitually struggle due to rapidly changing customer needs with the quandary of increasing product variant are product complexity. The proposed methodology concentrates on combining FUZZY DEMATEL & FUZZY TOPSIS to recognize the customer preference which makes easier way to fortify the product configuration. FUZZY DEMATEL enhances the customer preference for generating design characteristics and FUZZY TOPSIS will prioritize the importance of design characteristics to achieve product configuration .The structure framework gives us product configuration through which customer priority can be easily achieved.

KEYWORDS: Customer preference; Customer perception; Fuzzy Dematel; Fuzzy Topsis; CCi (Closeness Coefficient); HoC (House of Quality);VOC (Voice of Customer); hybrid techniques;

Chin-hsuan wang, juite wang 2014 explains that hybrid techniques has been proposed in order to convert market requirement into engineering characteristics ,through which the customer weightages identified .The combination of Fuzzzy AHP and Fuzzy Kano has been implemented as hybird technique to recognize the customer preference for core attributes and customer perception for optional attributes. Chin-hsuan wang2012 suggested Fuzzy Delphi technique gathered the customer requirement and technical attributes for generating pairwise comparisons among market requirements. In addition to the fuzzy Delphi technique, the LIP technique provides tradeoff between final weightage of MR's and TA's. For obtaining final weights between MR's and TA's LIP Linear integer program method is adpated. Yanlaili, Joith Tang 2009 according to Y ,Tang, new method PHOQ is identified the core customer requirements determined the core attributes ,Rough Set theory is used for illustrate the final important weightage ranking. Yue Wang 2011 analysis multi-criteria parameter required for a qualitative and subjective factors which is closer to the customer's needs. To explode closer requirement Navis Bay's approach is proposed.

According to Nicheel Stenes 2016 EVAS (Evoked set based attribute selection method find out appropriate levels of the customers perspective recently most of the past researchers were focusing customer preference. Even though selection of attribute and levels of preference measurement are important to meet the customer need, many of researchers concentrated much on estimation method and swing method. Xiozhen 2016 explians the shape technical attribute relationship in a better manner QFD is applied and similarity preference are identified through Fuzzy technique henceforth they design and manufacturing gap can be reasonably utilized. Stetan HOC matrix 2015 HOC (House of Quality)implement in the conceptual stage to customers' needs HoC reduces the time and cost. Development and implement stage will give better result.

Product development concept evaluation. Design concept evaluation has been introduced to consider for difference like design criteria, work identification, design team members. To satisfy all above criteria VIKOR method were applied to find the initial weight design criteria for designers to make decision. (Varun Tiwari 2016) To integrate customer needs and technical attributes ECQFD- Environment Friendly Factors. Fuzzy AHP - Customer's preference has been indentified. TRIZ- for better alternative .To reach design concept successive Eco-Friendly has been implemented (Vinoth.S2014). A Novel approach Chih Hsuan Wang. Intergation of AHP, KANO, DEMATEAL sharpen the relationship between marketing requirementing and design attributes (Chih

hsuan wang 2013). Integration of Kano's model.(VOC) Voice of Customer are identified through customers survey data. Then, survey data are converted into technical attributes through customers perception by applying kano's model by which difference levels of customers requirement has been observed (Ankur chaudha 2011).

In this research, the proposed method concentrated on Fuzzy Dematel to find the customer preferences and Fuzzy Topsis to identify product configuration. For better understanding the comparison between the proposed technique and previous research work has been summarized in Table.1 The QFD identify the marking requirements and customer needs by prioritizing the Engineering characteristics. Further many researchers used Fuzzy AHP for customer preferences and they mainly focused on Funny kano model for analyzing customer perception. To sharpen the product configuration they implemented EVAS, VIKOR, HoC, TRIZ methods for better product design as a final stage. whereas the proposed method gives readiness to the market by combining Fuzzy dematel and Fuzzy topsis. The identification similar rating between customer exact needs meets challenging task for every product design engineer which can be done by fuzzy topsis method. By skipping QFD and Fuzzy kano method, the time consumption can be improved by combining fuzzy dematel and fuzzy topsis techniques through which appropriate customer preference can be identified easily.

Table 1: Justification and Gap Identified

Author	Comparison between Business Requirement and User requirement	Customer preferences	Customer perceptions	Product Configuration	Business Model
Xiozhen	QFD	Not relevant	Not relevant	Fuzzy Topsis	Not relevant
Michael Steiner	QFD	Not relevant	Not relevant	EVAS	Not relevant
Varun Tiwari	QFD	ROUGH SET	Not relevant	VIKOR	Customer preferences
Stefan Punz	QFD	Not relevant	Not relevant	HoC	Not relevant
S. Vinodh	ECQFD	FUZZY AHP	Not relevant	TRIZ	Moderate Price
Chih-Hsuan Wang	QFD	FUZZY AHP	FUZZY KANO	ZERO ONE INTEGER PROGRAMMIN G	Moderate Price
Chih-Hsuan Wang	Dematel	AHP	KANO Model	AHP	Customer preferences
Chih-Hsuan Wang	QFD+ Fuzzy Dematel	Not relevant	Not relevant	Linear integer programming	Moderate Price
Yue Wang	Not relevant	Naive Bayes	Not relevant	Not relevant	Customer preferences
Ankur Chaudha	QFD	N/R	KANO Model	Not relevant	Customer preferences
Yanlai Li	PPHOQ	ROUGH SET	KANO Model	FUZZY AHP	Moderate Price
Proposed Research	Not relevant	Fuzzy Dematel	Not relevant	Fuzzy Topsis	Customer preferences

Business Requirement

By ranking the business requirement the proposed method can attain the manufacturing goal,

reduced working expenditure, product reach the market, before competitor products.

User Requirement

To fulfill the customer stratification, the proposed method converts business requirement into user requirement (Scrubbing width, Suction width, Theoretical area coverage.etc) in an apporiatate way.

Functional Requirement

Based on the collection of the customer feedback for the previous product, the proposed method functional requirement (Noiseless quiet operation, Eay to wipe and wash clean, Easy repairing and maintenanace.etc) has been improved. The remainder of this paper is organized as follows:

RESEARCH MODEL

The schematic diagram of figure1 deals about requirements from various customers which includes Fuzzy Dematel and fuzzy Topsis to fulfill the challenges of today's market requirement.
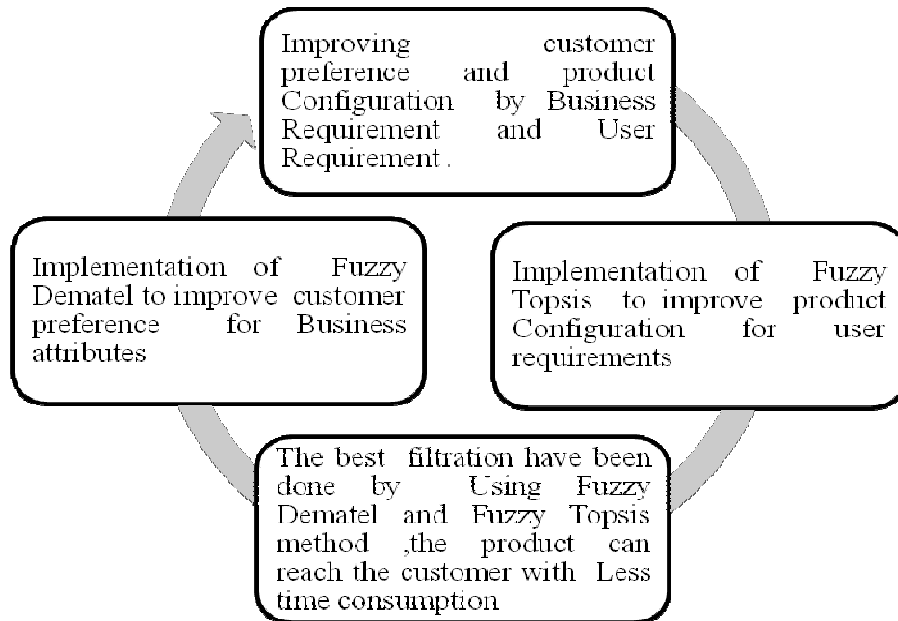
METHODS

To improve the customer Preference and product Configuration by Business Requirement and User Requirement follows the steps describe below:

Fuzzy Dematel: implementation of Fuzzy Dematel to improve customer Preference for Business attributes.

Fuzzy Topsis: implementation of Fuzzy Topsis to improve product Configuration for user requirements.

Finally, the best filtration have been done by Combining Fuzzy Dematel and Fuzzy Topsis method, the product can reach the customer with less time consumption.

FUZZY DEMATEL TO IMPROVE CUSTOMER PREFERENCE FOR BUSINESS REQUIREMENTS

The pairwise comparison among different criteria have been included for the proposed technique. The important lingusitics variables considered are 1.No influence 2. Very low influence 3. Low influence 4. High influence 5. Very High influence which are framed as business requirements. The mean pairwise comparisons between different criteria noted as Hij and (lij,mij,uij) are Triangular Fuzzy numbers.

$$H_{ij} = \frac{Z_{ij}}{r} = \left(\frac{l'_{ij}}{r}, \frac{m'_{ij}}{r}, \frac{u'_{ij}}{r} \right) = (l'_{ij}, m'_{ij}, u'_{ij})$$

$$\left[l^t_{ij} \right] = H_t \times (l - H_l)$$

$$t_{ij} = (l^t_{ij}, m^t_{ij}, u^t_{ij})$$

$$\left[l^t_{ij} \right] = H_t \times (l - H_l)$$

$$[lM_{ij}^t] = H_m \times (l - H_{lm})$$
$$[ul_{ij}^t] = H_{ut} \times (l - H_{lu})$$

Where $[l_{ij}^k], [m_{ij}^k], [u_{ij}^k]$ represents Triangular Fuzzy matrix and Then Total Relation fuzzy matrix is represented as $(\tilde{D}, \tilde{R})$ Which are different row and column matrix.

$$D = (D_i) = \left[\sum_{j=1}^{n} T_{ij}\right]_{n \times 1}$$

$$R = (R_i) = \left[\sum_{J=1}^{n} T_{ij}\right]_{1 \times n}$$

Finally the strength of connection of other factors have analyzed by as $(\tilde{D} + \tilde{R})$ and gives $(\tilde{D} + \tilde{R})$ degree of casual relation which useful for the further analysis of proposed method.

FUZZY TOPSIS TO IMPROVE PRODUCT CONFIGURATION FOR USER REQUIREMENTS

The Important concept of this method is to select the suitable alternative on the basis of shortest geometric distance from the positive ideal solution and longest geometric distance from the negative ideal solution. The important linguistics variables considered are 1.Very Poor 2.Poor 3.Medium Poor 4.Fair 5. Medium Good 6.Good 7.Very Good which are framed as user requirements. To create an estimate matrix by identifying Alternatives and Criteria with the juncture of each alternatives and criteria are given as weighted decision matrix $\tilde{R}$

$$R = [r_{ij}]_{m \times n} \quad i = 1,2,3\dots, m \quad j = 1,2,3\dots,$$

Weighted decision matrix rij and the matrix includes criteria of user requirements as cj and matrix includes alternatives of user requirement as aj:

$$r_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right)$$

$$c_j^* = Max\ C_{ij}$$

$$r_{ij} = \left(\frac{a_j^-}{C_{ij}}, \frac{a_j^-}{C_{ij}}, \frac{a_j^-}{C_{ij}}\right)$$

$$a_j^- = Mini\ a_{ij}$$

$$V = [v_{ij}]_{m \times n}$$

$$i = 1,2,3\dots, m \quad j = 1,2,3\dots,$$

$$V = r_{ij} \times w_j$$

$$d_i^* = \sum_{j=1}^{n} d\ (V_{ij} - V_{ij}^*)$$

$$i = 1,2,3\dots, m$$

$$d_i^- = \sum_{j=1}^{n} d\ (V_{ij} - V_{ij}^-)$$

$$i = 1,2,3\dots, m$$

The rank of considered alternative can be decide, according to the descending order of CCi*

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}$$

Finally the ranking between criteria and alternatives found by using Fuzzy Topsis to improve product Configuration for user requirements.

RESULTS AND DISCUSSION

Since cleaning and maintaining of Service sector, Industrial sector and Domestic sector are real challenge for every citizen. Hence this proposed research concentrate to design ride on scrubber machine to maintain the same. To enhance the performance of ride on scrubber, this proposed research gave better solution than any other technique. In this proposed research Fuzzy Dematel is used to improve customer Preference for Business Requirements and Fuzzy Topsis to improve Product Configuration for User Requirements.

FUZZY DEMATEL TO IMPROVE CUSTOMER PREFERENCE FOR BUSINESS REQUIREMENTS

Let us assume ride on scrubber machine includes business requirements are Working Speed, Theoretical Area Coverage, Suction Width, Faster Good Quality, Cleaning, Ego Friendly, Brush Motor Power and User requirements are Price Factor, Extra Brush Load, Reliable Safe and Secure, Drive Motor Power, Battery Rating and Low Power Consumption. The customer requirements are collected and further extraction of customer

requirements have been done by using Fuzzy Dematel. (see Table 2).

The priorities ranking has been ordered based on the weights from the customer preferences which is analyzed by using Fuzzy dematel as in table 2.the proposed fuzzy dematel prioritized higher ranking for Effective Suction Width, Working Speed, Price Factor and medium ranking for Theoretical Area Coverage, Travel Speed, Fresh Water Tank and also moderate ranking for Scrubbing width, Battery Rating,

Dirty Water Tank. As mentioned in the table 2, the data collected from the customers are combined as business requirements and prioritized using Fuzzy dematel. The higher have been given to the Effective Suction Width, Working Speed, Price Factor mentioned as (1,1*,1**), the medium priority have been given to the Theoretical Area Coverage, Travel Speed, Fresh Water Tank as mentioned as (2,2*,2**) and lower priority have been given to the Scrubbing Width, Battery Rating, Dirty Water Tank as mentioned as (3,3*,3**).

Table 2: The Extract Customer Preference through Fuzzy Dematel

Business Requirements	Weights	Priorities Ranking
Theoretical Area Coverage	12.85	3
Effective Suction Width	12.97	1
Scrubbing Width	12.96	2
Working Speed	7.93	2*
Travel Speed	7.63	3*
Battery Rating	8.77	1*
Price Factor	8.76	1*
Dirty Water Tank	7.90	2*
Fresh Water Tank	7.75	3*
Drive Motor Power	7.73	1*
Battery Rating	7.4	2*
Low Power Consumption	7.2	3*

FUZZY TOPSIS TO IMPROVE PRODUCT CONFIGURATION FOR PRODUCT USER REQUIREMENTS

In order to reach the closeness of the customer preference the proposed method designed a fuzzy topsis

to eliminate the similarities in customer preferences which are taken from the analysis of Fuzzy dematel. To refine in better level, the proposed fuzzy Topsis method designed for 12 criteria and 12 alternatives are taken into account for finding the priorities ranking through which product configuration have enhanced.

Table 3: Criteria and Alternatives

User Requirements	Closeness- coefficient [CCi]	Priorities Ranking
A_{11} Working Speed	0.216	2
A_{12} Theoretical Area Coverage	0.236	1
A_{13} Suction Width	0.125	3
A_{21} Faster Good Quality Cleaning	0.235	1*
A_{22} Ego Friendly	0.230	2*
A_{23} Brush Motor Power	0.221	3*
A_{31} Price Factor	0.268	1**
A_{32} Extra Brush Load	0.162	3**
A_{33} Reliable Safe And Secure	0.232	2**
A_{41} Drive Motor Power	0.264	1***
A_{42} Battery Rating	0.186	3***
A_{43} Low Power Consumption	0.187	2***

Based on relative closeness coefficient (CCi), the product configuration has been ordered with implementation fuzzy Topsis as in table 3.The proposed fuzzy Topsis prioritized higher ranking for A12 Theoretical Area Coverage, A21 Faster Good Quality Cleaning, A31 Price Factor, A41 Drive Motor Power are mentioned as (1,1*,1**,1***), and medium ranking for A11 Working Speed, A22 Ego Friendly,A33 Reliable Safe And Secure,A43 Low Power Consumption. Mentioned as (2,2*,2**,2***), and also moderate ranking for A13 Suction Width, A23 Brush

Motor Power, A32 Extra Brush Load, A42

Battery Rating mentioned as (3,3*,3**,3***) as in table.3. For best of our knowledge the comparison between Fuzzy Dematel and Fuzzy Topsis for different criteria and alternatives are shown in table 4 and the importance of ride on scrubber in various sectors based on its usage (Service Sector, Domestic Sectors and Industrial Sector) are shown in table 5. Final decomposition between Fuzzy dematel and Fuzzy topsis are clearly mentioned in Table.4 for which various requirements were collected from customers.

Table 4: Functional Decomposition of a Scrubber

Description	Specifications	Fuzzy Dematel	Fuzzy Topsis
Business Requirement	Working Speed	12.85	0.216
	Theoretical Area Coverage	12.97	0.236
	Suction Width	12.97	0.125
	Faster Good Quality Cleaning	7.83	0.235
	Ego Friendly	7.63	0.23
	Brush Motor Power	8.77	0.221
User	Price Factor	8.77	0.268
	Extra Brush Load	7.90	0.162
	Reliable Safe And Secure	7.75	0.232
	Drive Motor Power	7.73	0.264
Requirement	Battery Rating	7.4	0.186
	Low Power Consumption	7.2	0.189

As this proposed research analyzed the challenging task of finding quicker customer requirements, the usage of ride on scrubber machine in various sector have been analyzed by the survey taken from the customers are clearly displayed in the table.5.

Table 5: Optimizing Product Varieties for three market Segments

Requirements	Alternatives	Service Sector	Domestic Sectors	Industrial Sector
Business Requirement	A11		*	
	A12	*		
	A13			*
	A21	*		
	A22		*	
	A23			*
	A31	*		
User Requirement	A32			*
	A33		*	
	A41	*		
	A42			*
	A43		*	

After survey, the usage of ride on scrubber machine in service sector needs to improve in criteria (A12, A21,A31,A41). The usage of ride on scrubber machine in Domestic sector needs to improve in criteria (A11,A22,A33,A43). The usage of ride on scrubber machine in industry sector needs to improve in criteria (A13, A23,A32,A42).

CONCLUSION

In order to meet the customer requirements, the identification of customer requirements is challenging task. This proposed research concentrated on FUZZY DEMATEL & FUZZY TOPSIS to gave successful solution for challenging task of recognizing the customer requirements. FUZZY DEMATEL improved the customer Preference for Business Requirements and we designed a new Product Configuration for User Requirements using Fuzzy Topsis. Finally, Optimized Product Varieties for three market Segments were designed to find customer priority. Fuzzy Dematel improved customer Preference for various Business Requirements by ordering the priorities ranking based on the weights from the customer preferences. Fuzzy Topsis enhanced Product Configuration for different User Requirements by calculating the closeness of the customer preference to eliminate the similarities in customer preferences which are taken from the analysis of Fuzzy dematel. In future research further analysis can be done using TRIZ, DEA techniques to prioritize customer needs.

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