Method to Detect Critical Characteristics of Light Construction Products from the Voice of Customer

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Abstract--**In the construction sector it is important to have continuous improvement and innovation of products due to the continuous change of market trends. To remain competitive, it is necessary to identify customer needs and translate them into technical product characteristics. This research aims to determine the critical characteristics of light construction products from the voice of customer, based on a specific product from the family of joint compounds. To achieve the objective, a combination of interviews and observations techniques are used to obtain customer feedback; then affinity diagrams are used for grouping and classification of comments, finally these comments are organized and translated into critical characteristics of a product by using a matrix based on the QFD "House of Quality". The principles applied in this matrix are: difference between negative and positive comments, customers´ priorities of the given comments, and comparison of product development against other manufacturers. Product monthly average shipments will be measure for the validation of the effectiveness of the method.**

I. LIGHT CONSTRUCTION (DRYWALL SYSTEM) CURRENT STATUS

Since its start in the US around 1900's Light Construction (Drywall System) has increased its presence around the world as it offers different advantages and benefits for architectural constructions among which are: (1) use of recycled materials, (2) installation speed twice faster than the traditional system, (3) it saves up to 50% on construction foundation cost, (4) better performance on thermal and acoustical properties than the traditional system, (5) up to 30% more energy saving than the traditional system (6) the cleanest construction system in the market [12].

In countries like Argentina the consumption of drywall has increased six times over the past 15 years as it increased from 0.1 m² per capita in 1997 to 0.6 m^2 in 2011. The South American average of consumption in 2011 was approximately 0.33 m² per capita, still they were far from the 2.5 m² per capita of Germany, or the 12 m² per capita that were consumed per year in the United States [9].

II. PROBLEM STATEMENT

There are several methods for gathering and processing the voice of customers (VOC), these methods are either too shallow or too complex. In particular for light construction market it is required a methodology that can translate customer needs into product improvements and innovations from customers that do not clearly express their needs due to the use of colloquial words and basic or non-academic preparation. Usually these needs are based on previous experience or knowledge passed between generations, so it is common to hear similar or different terms that may refer to different or similar properties of products, for example a common expression for product performance is "The product is heavy", this expression can refer to product weight, viscosity, workability, etc. Or "The product is hard", this expression can refer to product viscosity, workability, drying time, etc.

This uncertain information received from customers makes it more difficult to determine what characteristics or properties of products are critical and need to be improved or modified so that they receive better acceptance?

III. RESEARCH OBJECTIVE

Design and implement a practical method to detect critical characteristic of light construction products from the Voice of Customer.

IV. RESEARCH JUSTIFICATION

Each company is proud to argue that it gives its customers what they ask for [17]. But in the new trade environment, the clients are no longer passive entities that simply accept whatever companies offer. Today consumers have prior information about what they wish to purchase and have the tools that allow them to compare between brands. They know that their preferences can be covered by any company that understands their needs [3].

Innovative organizations have a formal VOC process to capture, translate and transform customer needs into measurable internal process. Traditional methods like questionnaires, complaints gathering and processing, sales force as the face of customers are not enough to capture customer's real needs. New tools allow to find an "anthropology of the customer" in such a way that organizations can understand not only how customers "use" a product or service, but how an offer creates forms of life, interactions, connections, solutions and even alternative uses that were unknown [16].

There are several methods to acquire, analyze and understand the VOC (Table 1), some of them are too shallow and traditional, and others are too complex but newer, these methods were analyzed and taken as a basis to design a practical method as it was established in the research objective.

TABLE 1. METHODS TO OBTAIN, ANALYZE AND UNDERSTAND THE VOC.

Shallow and traditional	*Complex and newer*
Critical Incident Technique (CI)	Quality Function Deployment (QFD)
Customer Visit Teams (CVT)	Ethnographic Market Research (EMR)

V. CHARACTERISTICS OF THE ORGANIZATIONAL CONTEXT

In light construction sector the competitive advantage that an innovation will provide must be clear and explicit; otherwise the desire of the contractor or installer decreases [10].

The cost of an innovation is commonly considered as high for business in general and construction in particular as the time it takes to develop innovation and also testing can be costly [2].

Construction companies tend to differentiate between them in terms of cost, not in terms of technological skills, so usually innovation is not a viable option for achieving the competitive advantage strategy that construction companies are looking for because of the high expense of innovation processes [10]. This is why customers should be complete "partners" in the innovation process [1] because it has been shown that in 70% of construction projects, customers make important technical decisions and often share a high share of the risk associated with innovation [11].

The ideal is to look for a good understanding of user needs to be successful in innovation [4].

VI. RESEARCH METHOD

The method that will be designed begins with gathering opinions, complaints, needs, etc. of light construction products through direct interviews to installers; afterwards they are grouped for effective analysis in Quality Dimensions (QD) by using affinity diagrams. All Quality Dimensions identified are translated to technical characteristics of products and organized in a matrix called “Matrix of Critical Characteristics” which is based on the QFD house of quality [14], this matrix will emphasize in 3 different criteria to measure and determine if the technical characteristics identified are critical and its level of importance. Finally the critical characteristics are ordered by level of importance so preventive or corrective actions plans can be assigned to each one in further activities which are not taken on account in this method.

VII. METHOD DESIGN

A. Interview Design

The interview provides a descriptive sense [18], because it aims to determine the critical characteristics of light construction products based on the use of them at the workplace. To accomplish an effective determination a step-by-step analysis of the building process is required [6]. The objective is to get feedback of the product performance in each stage, emphasizing in the characteristics that are considered to be essential to accomplish an excellent finishing.

If a comment does not apply to any of the products evaluated, the comment is not taken into account to continue the method [6], but it is registered separately because it might represent an opportunity to develop a new product.

A guide with key topics (Table 2) is developed to be able to follow an argument line during the interviews [8].

TABLE 2. EXAMPLE OF A GUIDE FOR LIGHT CONSTRUCTION PRODUCTS FROM THE FAMILY OF *JOINT COMPOUNDS*.

	Subject	*Characteristic*
1	*Preparation*	
	1.1	Paste appearance
	1.2	Facility to mix
2	*First Application*	
	2.1	Smoothness
	2.2	Working and drying time
	2.3	Finishing
3	*Second application*	
	3.1	Smoothness
	3.2	Working and drying time
	3.3	Finishing
4	*Finishing*	
	4.1	Smoothness
	4.2	Working and drying time
	4.3	Finishing

B. Organization of the Comments

The comments or incidents that are obtained during the interviews are grouped for effective analysis according to the similarities between them into Quality Dimensions (QD) using affinity diagrams (Fig. 1).

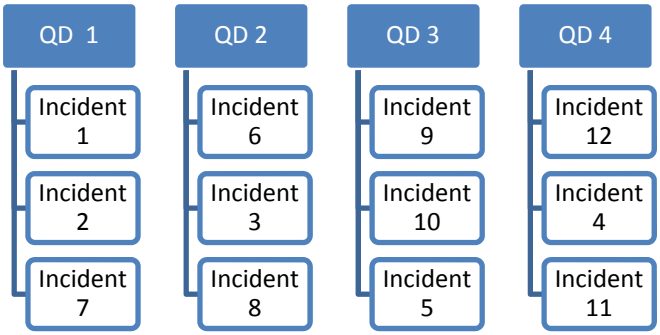

Fig. 1. Example or incidents grouping into Quality Dimensions (QD).

This diagram helps to relate the comments that are targeting the same product performance into one dimension that can be related to one technical characteristic of the product.

VIII. MATRIX OF CRITICAL CHARACTERISTICS

The QD's are organized in the "Matrix of Critical Characteristics", which is based on the principle of the QFD House of Quality [7], since it places the QD's in the rows of the matrix, but unlike the QFD House of Quality the technical characteristics related to these dimensions are placed in the same rows in a subsequent column.

The "Matrix of Critical Characteristics" emphasize in 3 different criteria, two are based on 2 steps of the "House of Quality" [14] considered to better comply the objective of this method, which are: (1) the level of importance according to the customer and (2) the comparative of product performance vs. competition; the third criterion is the balance of positive and negative comments about the products performance; for each QD these 3 criteria are evaluated and given a numerical value so it can be determine if the related characteristic is critical and its level of importance.

The third criterion "balance of positive and negative comments" is added to determine performance trends (negative or positive), so preventive actions can be taken, and to confirm if a characteristic is critical [5], because if there is no change in comments then the characteristic is not making any effect in customers perception so it is not critical or stopped being critical due to a change in market trends, so it can be removed from the Matrix.

A. Matrix of Critical Characteristics Design Procedure

Frequency Section.

The name of the product is placed in the top of the Matrix, the subjects from the interview guide are placed in the first column and the QD's are placed in the subsequent column, then the principal step of the method takes place, a group of people with technical knowledge of the products relate the QD's with a technical characteristic of the product that affect each one in a positive or negative way, the characteristic determined is placed in the third column and it is consider critical because it affects a group of related incidents. Finally the number of positive or negative comments obtained by installers is placed in the fourth and fifth columns as appropriate (Table 3).

Direction and Magnitude Section.

In this section takes place the analysis of the 3 different criteria, so the magnitude and direction of the critical characteristics can be calculated (Table 4), therefore this section is key to determine if a characteristic remain critical during different periods of time, depending on customers perception.

Criterion 1: determines direction and frequency of the critical characteristic, it measures how frequently is an incident mentioned either positively or negatively by subtracting the positive to the negative comments, the magnitude of the value indicates how frequently the comment was heard and the sign indicates if it is a strength or a weakness. This criterion helps to validate the effectiveness of the product improvements.

Criterion 2: determines level of importance of the critical characteristic, the QD's established are continuously monitoring with customers to determine the level of importance that they give to the related incidents, so a priority to activate preventive or corrective actions to each critical characteristic can be established. A scale of 3 levels is used which include low (1), medium (2) and high (3). The final average obtained from all clients is places in the matrix.

Criterion 3: determines the market place, customers are requested to compare the product against direct competition according to their perception, a 3 levels scale is used which includes whether the product is better (1), equal (2) or worse (3) than the competition, a "0" is placed if not applicable. The final average obtained from all clients is placed in the matrix.

TABLE 3. "MATRIX OF CRITICAL CHARACTERISTICS" FREQUENCY SECTION.

Product:

Subject	Quality Dimension	Critical Characteristics	Comments	
			-	+
Subject 1	*QD 1*	Characteristic 1	-n	+n
	QD 2	Characteristic 2	-n	+n
	.	.	.	.

TABLE 4. "MATRIX OF CRITICAL CHARACTERISTICS" DIRECTION AND MAGNITUDE SECTION.

		Criterion 1	Criterion 2	Criterion 3
Frequency Section	....	Balance	Client importance	Comparison against competition
	....	Comments(+n) – Comments(-n)	1, 2 o 3	0, 1, 2 o 3
	....	.	.	.
	....	.	.	.

Positive or negative comments are added to the previous ones if the matrix is applied in different periods regardless if the same customer was interviewed or if he/she changed his mind; however if the balance of a critical characteristic is less than 9 and comments stop flowing or is equal to 9 and positive comments are keep coming, the addition of positive comments stops because this means that characteristics have been fully improved and if it the market trend suddenly change to the negative side, it will only require 10 comments (a third of a representative sample of 30 customers) to re-activate the characteristics.

In criteria 2 and 3 since an average is calculated the value in the matrix is only updated with the average obtained in the last period of application. With this form of measurement it is possible to obtain a dynamic matrix which helps to predict market trends, warns of possible changes and helps to verify that the actions taken to improve critical characteristics are being effective.

If the critical characteristics determined at the beginning do not present changes in all their criteria values in further interviews, means that customers no longer considers them important or they have been fully improved, therefore they cease to be critical and they are removed from the matrix.

Results Section.

For the final grade, the values of the 3 criteria are multiplied, if the result is lower than "0" the critical characteristic requires improvement and it will be more critical as it decreases in magnitude, if it is greater than "0" indicates that the critical characteristic is momentarily at a favorable status and it will be a strength as it increases in magnitude, however there is one exception, when customers believe that the product have a positive performance but below the competition performance the final results is multiplied by (-1) to indicate that there is a need for improvement (Table 5).

At the bottom of the Matrix the characteristic of "price" is always placed to monitor the value that the customer gives to product improvements, however the comparison of price usually depends on the reference point, which can be:

1. A similar product offered by the manufacturer but whit different properties. Here the differentiation must be clear for the customer.
2. An estimate given by the customer perception. This depend on the estimate value given by the customer, how good does the product solve customer's needs?
3. The direct comparison with the price of a similar product from a competitor.

The price is considered critical because if the product have a "commodity" performance, then it is critical to avoid a possible "overshooting" due to unnecessary improvement or innovations.

To finalize the "Matrix of Critical Characteristics" the critical characteristics with negative results are sorted in ascending order in the last columns to determine the priority with which the improvement processes will initiate (Table 6).

TABLE 5. "MATRIX OF CRITICAL CHARACTERISTICS" RESULTS SECTION.

Frequency Section	Direction and Magnitude Section	Result	Order	Critical Characteristics to Improve
....	....	X	1	**Characteristic 1**
....	....	Y	2	**Characteristic 2**
....	....	….	3	**Characteristic n**
....	....			
....	....			

TABLE 6. "MATRIX OF CRITICAL CHARACTERISTICS" FORMAT.

Product:					MATRIX OF CRITICAL CHARACTERISTICS					
Subject	Quality Dimension	Critical Characteristics	Comments		Criterion 1	Criterion 2	Criterion 3			
			-	+	Balance	Client importance	Comparison against competition	Results	Order	Critical Characteristics to Improve
Subject *1*	*QD 1*	Characteristic 1	-n	+n	(+n) – (-n)	1, 2 o 3	0, 1, 2 o 3	X	1	**Characteristic 1**
	QD 2	Characteristic 2	-n	+n					2	**Characteristic 2**
	QD n	Characteristic n	-n	+n					3	**Characteristic n**
Subject n									4	
Price		Price							5	

TABLE 7. SEGMENTATION OF PERIODS OF TIME AND AMOUNT OF INSTALLER INTERVIEWED IN EACH PERIOD.

	1st Period	*2nd Period*	*3rd Period*
Time	Dec-12 to Feb-13	Mar-Jun 2013	Jul-Oct 2013
Installers Interviewed	45	31	20

If there is a case where a critical characteristic is required to be improved by some customers but the improvement will contrast with the requirements from other customers, then there is an indicator that a new product or a variant of the actual one is needed to be developed.

B. Method implementation.

To determine the effectiveness of the method developed, it was implemented in a Gypsum Board Company in north of Mexico, to detect the critical characteristics of a specific light construction product from the family of joint compounds, which are pastes used to fill in gypsum board joints to vanish them for a smooth finishing.

C. Sample description.

The interviews were carried out in the state of Texas in the United States because the Company where the study was conducted was already selling joint compound in this area. Also because from all the markets that the base Company is selling this product, this is the one with the highest experience in applying joint compounds for light construction systems and with the highest level of competitions.

The interviews were applied by one Technician directly to 96 installers divided in 3 different periods of time, the same Technician interviewed in all periods, so the feedback obtained in each period could demonstrate movement in the 3 criteria from the "Matrix of Critical Characteristics" (Table 7).

The installers were determined to be the principal customers because they are the final users of the joint compounds and the ones who can give effective feedback of product performance. Installers interviewed in each period were male with basic or none education and with more than one year of experience applying joint compound in one or more cities in the state of Texas and some abroad, also they are used to similar forms of application distinctive from Texas. They could have participated in interviews done in previous periods or it could be their first time as the dynamism of the measurement in the matrix allows this form of "selection" of sample due to the difficulty to interview the same installers because of the rotation they have in their line of work.

IX. RESULTS AND DATA ANALYSIS

A. 1st Period.

Comments about actions or non-common events both positive and negative were obtained and considered as critical incidents [15], they where also considered critical according to the first criterion of the Quality of the Critical Incident Technique since they described crucial demands during the application; these comments were grouped using affinity diagrams so the Interviewer could determaine Quality Dimensions [5] as follows (Fig. 2):

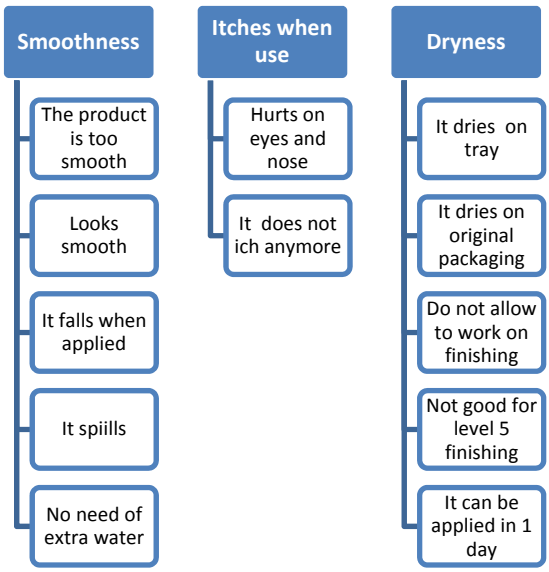

Fig. 2. Grouping of incidents (examples) in quality dimensions for the joint compound evaluated.

Based on the expertise of the interviewer and the base Company work team, the Quality Dimensions were related to 3 critical characteristics: Viscosity, Toxicity and Working time respectively; which were added to the "Matrix of Critical Characteristics" (Table 8).

After the 3 criteria analysis was applied it was clear that in first criterion only one critical characteristic had negative behavior (Fig. 3) so in only one quality dimension the negative comments exceed the positive, therefore an improvement needed to be done according to the second criterion of the Quality of the Critical Incident Technique, since it described behaviors that were discriminated between successful or less successful for the performance of joint compound [5].

With second and third criteria it was clear that all critical characteristics were considered important and only one performed worse than the product of the competition.

TABLE 8. "MATRIX OF CRITICAL CHARACTERISTICS" DETERMINED FOR 1ST PERIOD.

Product:	Joint compound		MATRIX OF CRITICAL CHARACTERISTICS							
Subject	Quality Dimension	Critical Characteristics	Comments		Criterion 1	Criterion 2	Criterion 3			
			+	-	Balance	Client importance	Comparison against competition	Results	Order	Critical Characteristics to Improve
Preparation	*Smoothness*	Viscosity	14	3	-11	3	3	-99	1	**Viscosity**
Second application	*Itches when use*	Toxicity	1	8	7	3	2	42	2	-
	Dryness	Working time	15	17	2	3	1	6	3	-
Price		Price	1	10	9	3	2	54	4	-

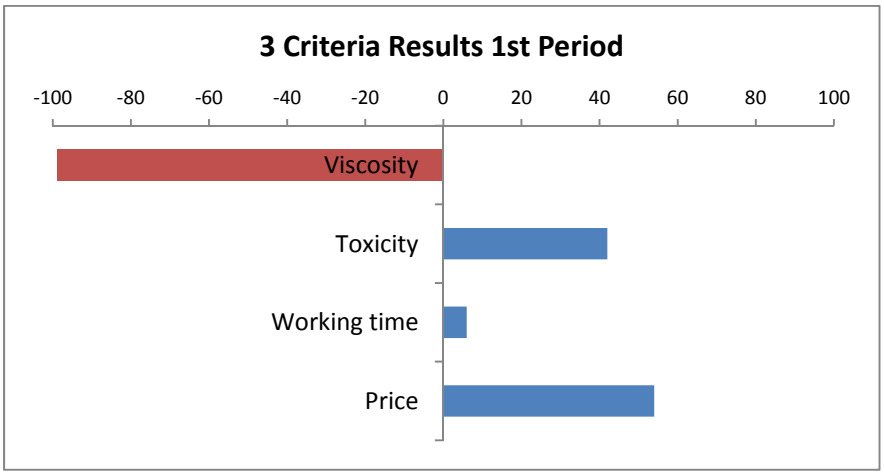

Fig. 2. Magnitude and direction for the critical characteristics determined.

So for the first period the following critical characteristics that modified the Quality Dimensions were obtained (Fig. 4):

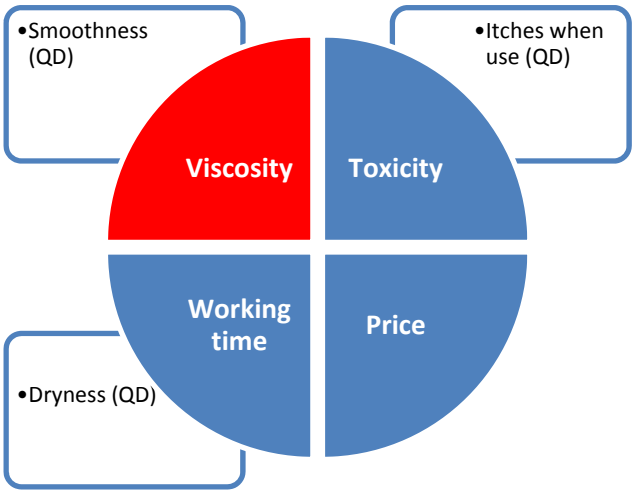

Fig. 3. Critical characteristics determined to respond to each Quality Dimension.

These characteristics could be modified so there was no need to develop a new product. The only characteristic that needed to be improved was the "Viscosity".

This first approach was very accurate but the effectiveness increased as the matrix was actualized later on next periods. In March and April 2013 operational improvements in the process were made to improve "Viscosity" and pilot samples were sent to the market to evaluate the acceptance of installers.

B. 2nd Period

The interviews were applied again to the market and similar comments were obtained so they were just added to the Quality Dimension in which they were related, but this time some other comments not related to the previews ones were also obtained, so 2 new Quality Dimensions had to be added: Finishing and Quick Drying (Fig. 5).

Based on the affinity diagram (Fig. 5) the "Matrix of Critical Characteristics" of 1st period was complemented to analyze 2nd period (Table 9). In this period two critical characteristics were related to the new Quality Dimensions: Adherence and Drying Time. The rest of the critical characteristics remained equal.

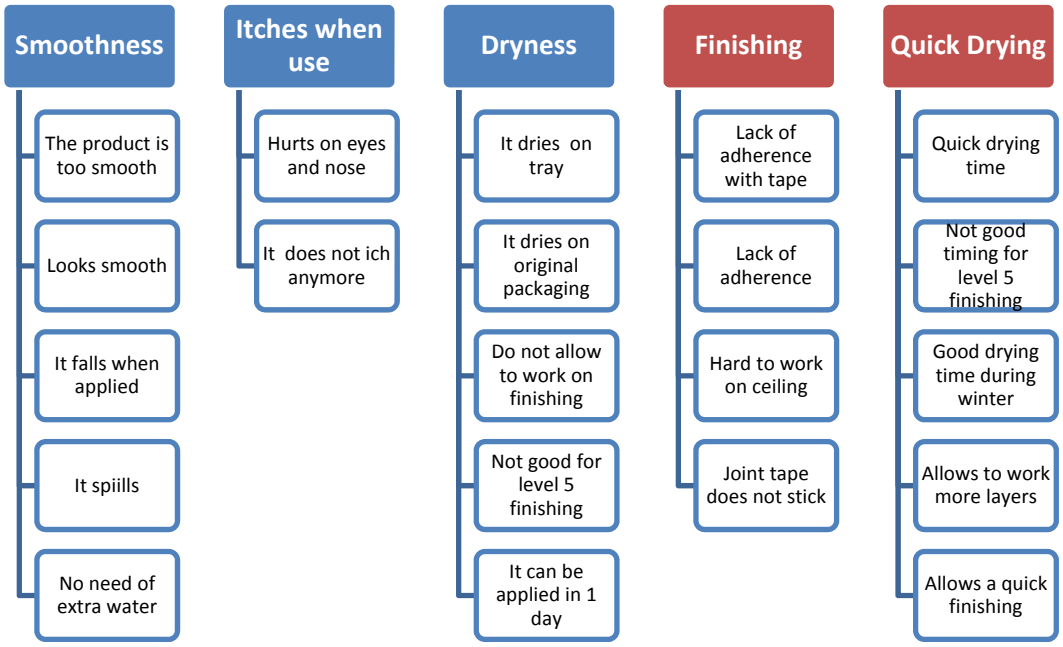

Fig. 5. Grouping of incidents (examples) in quality dimensions for the joint compound evaluated.

TABLE 9. "MATRIX OF CRITICAL CHARACTERISTICS" DETERMINED AND UPDATED FOR 2ND PERIOD.

Product:	Joint compound				MATRIX OF CRITICAL CHARACTERISTICS					
Subject	Quality Dimension	Critical Characteristics	Comments		Criterion 1	Criterion 2	Criterion 3			
			-	+	Balance	Client importance	Comparison against competition	Results	Order	Critical Characteristics to Improve
Preparation	*Smoothness*	Viscosity	18	3	-15	3	3	-135	1	**Viscosity**
First application	*Finishing*	Adherence	12	0	-12	2	3	-72	2	**Adherence**
Second application	*Itches when use*	Toxicity	1	10	9	1	2	18	3	-
	Dryness	Working time	15	17	2	3	1	6	4	-
	Quick drying	Drying time	4	7	3	2	1	6	5	-
Price		Price	3	10	7	3	2	42	6	-

The 3 criteria analysis was applied to the critical characteristics and the values were actualized, the amount of positive or negative comments in criterion 1 were added to the previous comments from 1st period and the final balance were calculated, the averages of criteria 2 and 3 were recalculated for this new period according to the new perception from installers.

It can be seen in Table 9 how some of the values of criteria 1 and 2 for the characteristics identified in 1st period changed in 2nd period (Fig. 6), for example the characteristic "viscosity" had a smaller amount of negative comments than in 1st period, this fact indicates that the improvement actions taken after the interviews done in 1st period caused a change in the product enough to reduce the amount of negative comments, however these actions were not 100% effective because the positive feedback did not increase, so the changes reduced the negative comments but were not enough to change installers perspective. On the other hand the characteristic "toxicity" got more positive comments, which increased the balance to the positive side, this means that the characteristic was fully improved thanks to actions taken to eradicate the poor performance in 2012; therefore the installers changed their priorities to target other characteristics and stopped worrying about this one. It is important to highlight that not all improvements are immediately notice or valued by customers; sometimes it takes a while for installers to appreciate and accept products improvements due to the wide variety of options available in the market and the high price competition.

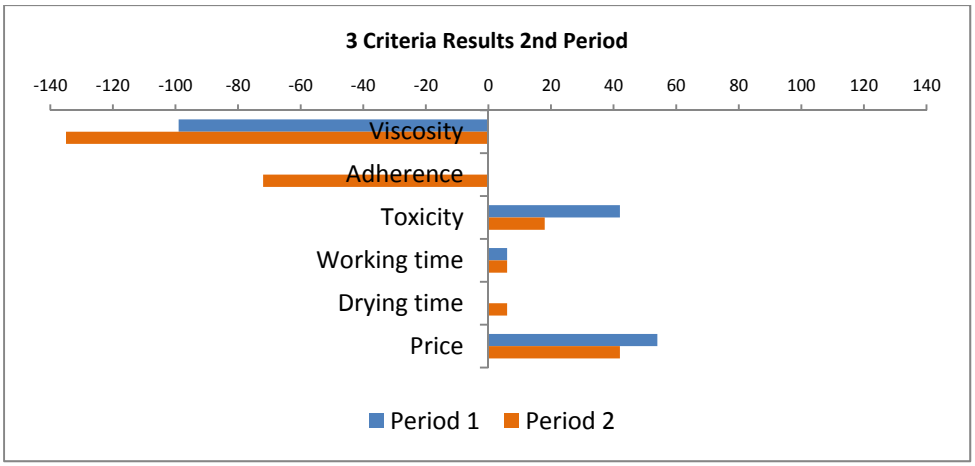

Fig. 6. Magnitude and direction change for critical characteristics from 1st to 2nd periods.

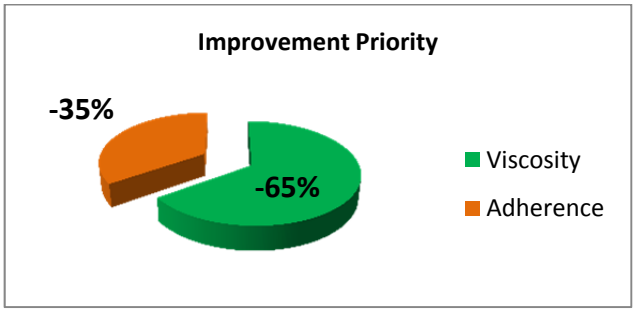

Fig. 7. Product critical characteristics priority according to the 3 criteria analysis.

After calculating the 3 criteria results for all the critical characteristics in the matrix for 2nd period (Table 9) it was confirmed, according to what was stated before, that all critical characteristics obtained in 1st period remained being critical because they had changes in their 3 criteria behavior, also the new characteristics determined in this period "adherence" and "drying time" were considered critical because of they were also highlight by installers and they have movement in the 3 criteria values, they were monitored in next period to confirm. In this period "viscosity" repeated as a critical characteristic which needed to be improved and "adherence" was also qualified for improvement, but according to their magnitude "viscosity" still had higher priority (Fig. 7).

Drastically improvements in "Viscosity" were done to the product during July 2013 which involved changes in raw materials, then the product was sent again to the market to measure the acceptance with installers, after period 2 there were no actions taken to improve "adherence" due to limited resources, so the priority order established in the matrix was followed.

C. 3rd Period.

In this period there were no extra Quality Dimensions determined and the ones already determined remained relevant (Fig. 5), so the "Matrix of Critical Characteristics" was updated according to the comments received (Table 10).

TABLE 10. "MATRIX OF CRITICAL CHARACTERISTICS" UPDATED FOR 3RD PERIOD.

Producto:	Joint compound				MATRIX OF CRITICAL CHARACTERISTICS					
Subject	Quality Dimension	Critical Characteristics	Comments		Criterion 1	Criterion 2	Criterion 3			
			-	+	Balance	Client importance	Comparison against competition	Results	Order	Critical Characteristics to Improve
Preparation	*Smoothness*	Viscosity	18	15	-3	3	3	-27	1	**Adherence**
First application	*Finishing*	Adherence	12	5	-7	2	3	-42	2	**Viscosity**
Second application	*Itches when use*	Toxicity	1	10	9	1	2	18	3	-
	Dryness	Working time	15	17	2	3	1	6	4	-
	Quick drying	Drying time	4	8	4	2	1	8	5	-
Price		Price	5	10	5	3	2	30	6	-

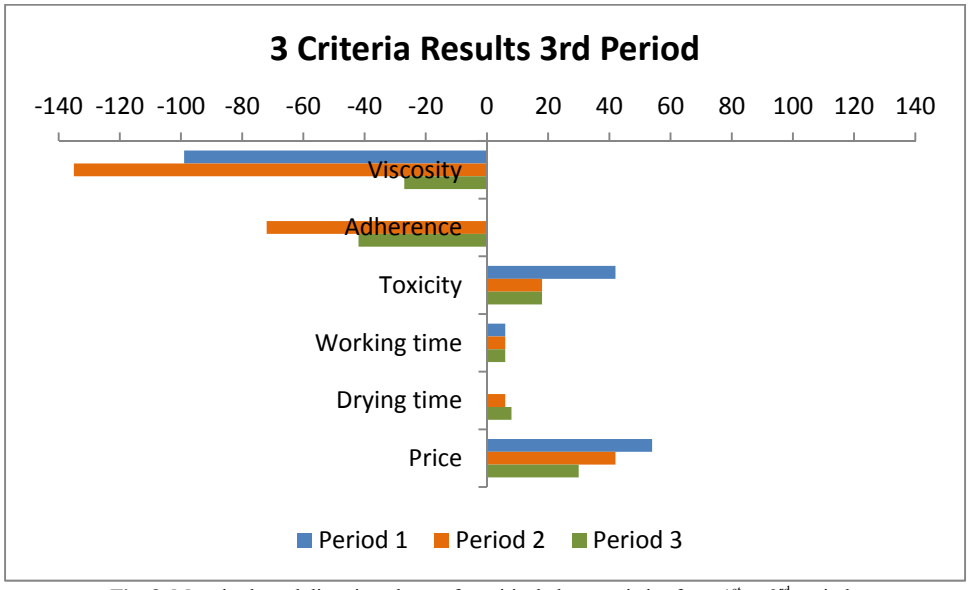

Fig. 8. Magnitude and direction change for critical characteristics from 1st to 3rd periods.

For this period it can be seen how some values of criterion 1 from characteristics detected on 2nd period changed again (Fig. 8), for example "Viscosity" increased in positive comments, which means that the drastically actions taken after 2nd period were more effective than the ones taken after 1st period, therefore the client perceived with higher magnitude a change in product and began making positive comments, but in spite of this the balance didn't cross the "0" line to the positive side, so the characteristic remained in the improvement list, but it was foreseen that in the next period it would disappeared from this list; in the other hand "adherence" had some positive comments thanks to the actions taken to improve "viscosity", however these actions were not directly applied to improve "adherence" so the magnitude of changes were minimum.

As it can be seen in figure 8 the magnitude of balance in "Price" has been decreasing during the periods evaluated, this indicates that the market is becoming more sensitive to product sale price, this can be due to:

1. The assigned value to the product by customer due to its quality is not justified "overshooting".
2. External economic factor (e.g. US economic recession).

Therefore it is becoming necessary to take actions to change this trend.

After calculating the 3 criteria results for all critical characteristics in the matrix for 3rd period (Table10) it was confirmed that most of the characteristics remained critical because they had changes in their 3 criteria behavior; however "toxicity" and "working time" did not had any movement in this period therefore they can be removed from the matrix because they stopped being critical for clients due to successful improvements or changing trends.

In this period "viscosity" was better qualified by customers so his magnitude of bad performance decreased and became 2nd place in the list for improvements, while "adherence" still remained as an opportunity for improvement and became 1st place (Fig. 9), then all efforts were re-directed to work on this characteristic.

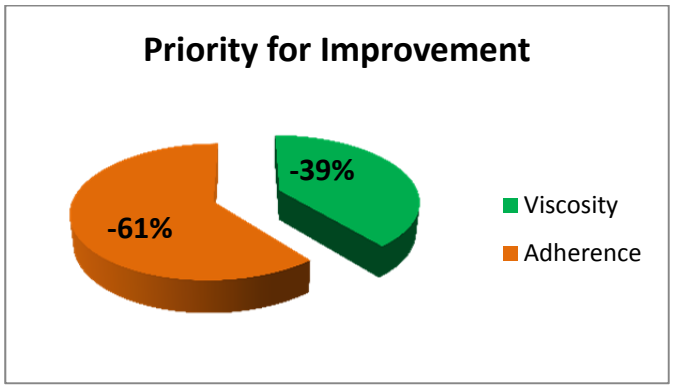

Fig. 9. Product critical characteristics priority according to the 3 criteria analysis.

X. METHOD VALIDATION

A validation of the designed method was done by measuring the amount of monthly product shipped during the period of January to October 2013 and compared it with the same period in 2012.

First the comparison was made by analyzing the monthly average of all 2012 period vs. each period of 2013 to analyze the benefit that each improvement accomplished in the market (Fig. 10).

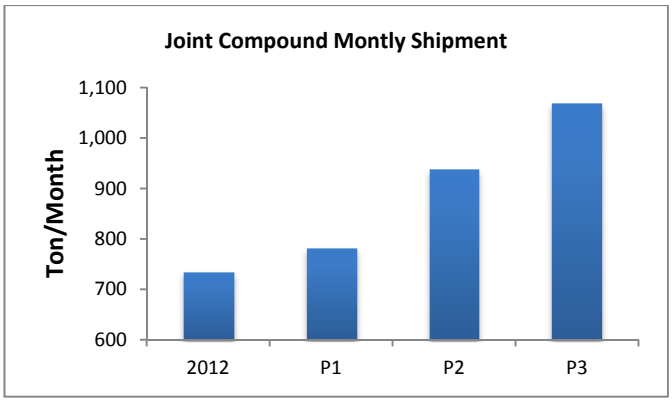

Fig. 10. Average monthly product shipment by period.

There was a slight increase of 6% in product monthly shipment during the 1st period of 2013 compared with monthly average shipment of all 2012, this increase was due to the improvement of the critical characteristic "toxicity" at the end of 2012, however the market was not receiving the product that completely satisfied their needs, because there was still a request for a product with better smoothness, therefore the critical characteristic "viscosity" was improved and sent to the market after 1st period.

In 2nd period the monthly shipment increased about 20% due to the change in perception of clients when they received the product with better smoothness. In 3rd period the increment in monthly shipment was only 14%, this happened because clients did not perceive a significant change in product appearance compared to previous period. This result was expected because the objective after 2nd period was to maintain product smoothness achieved after 1st period by modifying raw materials to return to stabilize operational conditions, so there was no significant change in product appearance.

Product monthly shipment trend was twice higher in 2013 than in 2012 (Fig. 11), this was equivalent to an approximate increase of 40 ton/month compare with the 20 ton/month accomplished on 2012, this increment matched the magnitude of increments reflected in each period, therefore it was directly related to changes made to product critical characteristics by period.

XI. CONCLUSIONS

Translate customer requirements to technical characteristics of a product and also be able to determine if they are critical is not an easy task. Therefore it is indispensable to establish methods that facilitate this "translation" and allow standardizing a procedure, however the actual methods are too shallow, complicated, complex or expensive, that is why in this study a practical and dynamical method was developed to facilitate the translation of the market requirements and analyze constant changes.

The critical characteristics that affected directly the quality dimensions were successfully determined thanks to the 3 criteria established, these criteria also allowed to monitor positive or negative trends in quality dimensions, this was confirmed after analyzing each period, therefore projects timing and cost are optimized for constant changing characteristics.

With these criteria the voice of customer was successfully translated into numerical values which gave magnitude and direction (positive or negative) to each characteristic so it was able to determine if they were critical and which had the highest priority to start the improvement process.

The method resulted to be an easy to use tool to determine critical characteristics of the products due to its structure and simplicity, so it was well adopted by the technician and people involved in the development process in the base Company.

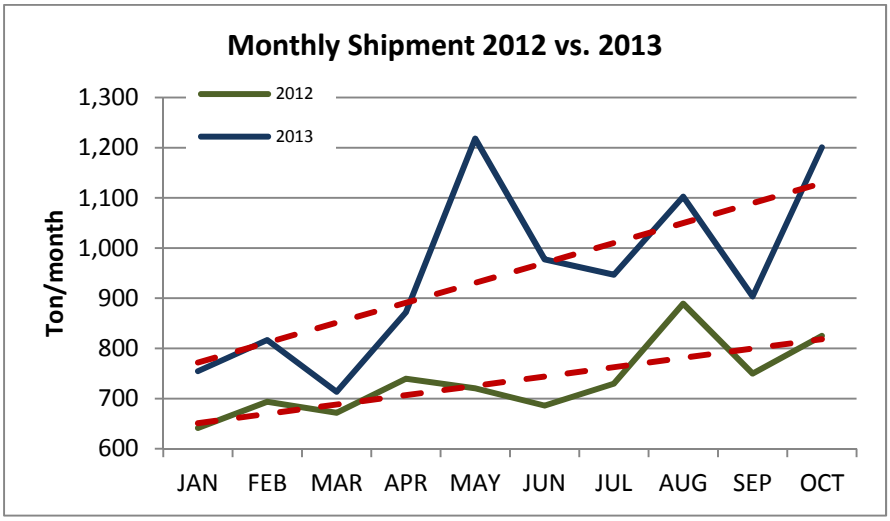

Fig. 11. Comparison of product monthly shipment of 2012 vs. 2013.

This method was the primary strategy of the base Company to increase joint compound sales in 2013 and the improvement of "Viscosity" in the product was the main change to increase product monthly shipment, so it can be validated that the method developed was effective to detect critical characteristics, because according to the analysis made of product monthly shipment in 2013 vs. 2012, the improvements made to "Viscosity" after each period, did increase product monthly shipment.

The method developed in this study was based on the current voice of customer methods which were mentioned in the research justification section, so it can substitute any of them, the substitution for the QFD method will depend on the scope require.

The key factor for the success of this method was to have involved installers in the process of product improvement. When installers were asked for their needs and then they experienced the changes that they requested reflected on the product, they felt part or the process and gave more support on the pilot test which reduced project cost [2].

XII. LIMITATIONS

The person who applies the interviews and makes the affinity diagrams has to have technical knowledge of the products that are going to be analyzed to increase effectiveness, because the installer's comments may be ambiguous.

The translation done in the Matrix of Critical Characteristics, it's more effective if it is done by a group of people with technical knowledge of the products.

The "Matrix of Critical Characteristics" is not as robust as the QFD "House of Quality" [13] since it does not take into account many aspects for improvement and innovation, however it takes into account 2 of the most important or relevant aspects for the clients in the construction sector as it was interpreted in the study of Na Lim & Ofori [10].

The critical characteristics established in the "Matrix of Critical Characteristics" are for a specific product and obtained from a specific geographic region (Texas, US), so they may not apply to every regions for the same product due to different forms of application distinctive from each region. Therefore a different matrix may be required for the same product for each region.

It was mentioned that economic factors may affect product price perception from customers, however these may also affect other characteristics results if the person interviewed is associating his responses only with price. Other factors that can affect results are loyalty to a specific brand and "buy domestic" policy.

This method was designed for a small or medium Company of the light Construction sector (less than 500 employees) with limited resources for development and innovation, the effectiveness in a large Company with more resources or different sectors (e.g. Traditional Construction, Food, Clothes, etc.) will need to be analyzed.

XIII. FUTURE RECOMMENDATIONS

It can be considered to apply this method in other type of industries to determine if the criteria established apply in other type of products and markets.

It will be interesting to analyze the necessity of implement other criteria not taken on account in this study, like the effect that a change on a product variable will cause to another variable.

It will be complementary analyze another form of validation of the effectiveness of this method to detect critical characteristics of products, in case the one used in this study is not consider to be accurate or does not take on account a hidden factor.

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