

Structured approach for the design and development of a technology push product with highly incorporated concept development phase

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Abstract—This study encompasses the steps involved in the design and development of a technology push product. It covers the various steps from the evolution of a product design concept from the initial stages of concept generation, hypothesized from the customer needs, to the final product architecture. The Technology Push Product considered in this study is an Electronic Cigarette. The selection of the product is novel in a manner that it brings an interesting alternative to normal cigarettes which have higher passive smoking dangers as well as health concerns. The research work highlights the dynamics of a structured product development process which conventionally begins with keeping various concepts in consideration. These concepts are evolved through customer surveys and Lead User opinions that help in determining initial product specifications. Various concepts are then formulated for the design of the product using different Design evaluation techniques such as Concept Combination Table. Viable concepts are then trimmed or modified based on some widely used concept selection techniques; concept screening and concept scoring are to name a few. The final Product Architecture is established once extensive Concept Development phase was completed. After this stage the concept is ready to go into prototyping and production and fine-tuning of the design can be done through Design For Manufacturing (DFM) operations.

Keywords—product design and development; Technology push; concept testing; concept selection; e-cigarette

I. INTRODUCTION

Product design and development plays the most vital role in the success of a product or service. A product that has undergone the complete product development cycle in a systematic approach will display characteristics that reflect the success of the product development effort by exhibiting high quality, low cost, less development time along with

high development capability ^[1]. All of these characteristics ultimately aim and aid in maximizing the success or profit of the product. Structured methods adopt a step-by-step approach in order to make the decision process explicit and help the design and development team to move forward with calculated and logical decisions ^[2,3]. It also helps in ascertaining that no important milestones have been overlooked. Although structured methods have their advantage but they only serve as a catalyst for continuous improvement ^[4] and therefore should be used with logical intuition. The technique followed in this study will highlight the effectiveness of a structured approach for record keeping in a decision making process and also its utility in making decisions with logical arguments ^[5].

The product considered in this study for implementing the structured approach is an Electronic cigarette which emits vaporized doses of nicotine that are inhaled directly without emitting ash or smoke. An E-cigarette consists of 4 major components; the atomizer, the heating vapor cell, the battery and the cartridge which includes the liquid vapor mixture. The product is battery operated and can also be used to emit non-nicotine based vapor. The product was selected as it is an alternative for an already established and thriving industry and will attract a large market share. The product is environment friendly and reduces passive smoking dangers greatly for the people in surrounding. The product may also be helpful for the patients undergoing Nicotine Replacement Therapy. This study entails the description of fundamental procedures adopted to provide a consumer friendly product that initiates from the phase of concept generation from initial product specifications and includes product architecture evolution after scrutinizing the concept through various concept testing and selection methods.

II. METHODOLOGY

A generic development process has been adopted to provide a product that meets the need of particular industrial situation. The product development process is a set of activities that evolve some random customer opinions into a tangible idea. The concept development process can also be evolved around a random idea with a better approach towards market, industry and the product itself. The aim of employing the structured approach is that a product has better quality, easily manageable and responds effectively towards changing market demands. The E-cigarette is an amalgam of platform product and technology push product as the normal tobacco cigarette already exists in the market but not with liquid nicotine or rechargeable battery. It was decided to launch a better version of the conventional tobacco inhalers i.e. cigarette. It will not only diminish the chances of passive smoking but will also assist the smokers in quitting. Following phases have been incorporated in the development of E-cigarette.

A. Planning

This phase is essential before taking on the market, investors and a bigger development team. The portfolio of the product is decided during this phase. It does not involve any hard and fast rules and can be updated at any time of the process depending upon changing market scenario or the customer demand. First step involves identification of opportunities which is the logical place to start. The fact that majority of men and a lesser amount of women are consumers of cigarette and a vast number of children are prone to passive smoking justifies a window of opportunity. This opportunity will not only generate a bigger market but will also help the society overcome the dilemma of chain smoking. A competitive strategy was designed to divert consumers from use of tobacco cigarette to liquid nicotine^[6]. This included introduction of environment friendly 'Green emissions' that will attract eco-friendly individuals. Emission of water vapors instead of smoke will reduce passive smoking. A mission statement was designed by focusing on the market dynamics^[7] and taking into account the basic product description, the proposed benefits, the key business goals, the target market and the stakeholders. The mission statement acts as the foundation stone for identifying customer needs and concept generation.

B. Identifying Customer Needs

A customer based survey was conducted to identify the basic requirements of the product. The

survey was based on the basic ingredients of the previously defined mission statement. The target customers were chain smokers and those who were willing to quit smoking. Two modes of interaction were used during the entire activity. Individual interviews were conducted and the use of cigarettes already existing in market was observed. After the interpretation of the raw data that was collected, metrics were evolved which depicted the requirement of the customer for the product. After creating the metrics statements the next step was prioritization of needs based on the purpose of the product and the generation of concepts based on the needs.

C. Concept Generation

An approximate description of the product was then developed in the concept generation phase. This activity provides a rough sketch of what the product looks like. The customer needs and target specifications were taken as the input. These helped in development of numerous concepts which fulfill the criterion for both categories. It is pertinent to mention here that a good concept may not always transform into an effective product but a bad concept is most likely to fail in the very early stages of the development process. Thus every possibility of the likely concept must be put forward and the most feasible ones are to be selected through a rigorous selection process.

In the concept generation phase the problem is first identified, clarified and decomposed. The problem identified was the provision of a better alternative of cigarettes which prevents passive smoking. The clarification of the problem is crucial in order to come up with a number of viable solutions which may be considered for the development process^[8]. A black box was generated to decompose the problem and reveal the sub problems involved in the process. Each sub function was further divided into simpler functions till they could be easily tackled in a focused way. Internal and external search^[2] was carried out to find out what it takes to cater the problems identified in the previous activity. Systematic exploration of possibilities for what the product could be made of was done. Concept combination table was chosen for this purpose to give multiple concepts that displayed the various configurations that the product may have along with the accompanying characteristics unique to each concept.

D. Concept Selection & Testing

The four feasible concepts earlier evolved in the development process were scrutinized through a selection process to provide an optimized solution.

There are numerous methods for selection of concept; going with intuition, multi voting and survey, considering pros and cons and going with the opinion of the product champion are to name a few. All of the mentioned methods have their own pits and falls, therefore, may end up in a chaotic solution with no guarantee of success. This generates the necessity of a more structured approach to cater the issue. In this study, two consecutive methods were adopted namely, concept screening and concept scoring. The methods are based on comprise comparative analysis with a reference product^[8] on the merits of different product attributes that are crucial to product design^[9]. It helps in rationally ascertaining the best optimized concept. After the product has evolved in its final shape, an evident testing procedure was required to check the feedback the product may receive from market. For this purpose, a survey was conducted among customers. The survey contains a brief introduction to the product and a questionnaire having few basic queries regarding smoking, the effects of passive smoking, how willing a customer would be to buy such a product which would remove passive smoking.

E. Product Architecture

The product architecture begins to emerge once a concept has been selected and tested. It takes up the form of sketches or initial proto types. It is thus the central element of product concept^[10]. A product has two aspects a functional and a physical aspect. Both of which, play a vital role in determining the utilization of the product. Thus it is essential to define the functional as well as physical parts of a product. The functional parts describe what functions a product can perform and physical parts are the building blocks of product also known as chunks. A product may be modular or integral depending upon the type of functionality of chunks. E-cigarette has been defined as a more modular product than integral. This is because the chunks such as the atomizer, LED and nicotine cartridge have one or more function and their interaction among each other is well defined. Whereas an integral product has a complex configuration and the interaction is not well defined. The product base which houses the liquid cartridge is designed so that different type of atomizers and battery may be attached to it at later stages to include product variation. After merging the product technology into a physical form the E-cigarette finally takes a portable shape which is easy to handle and use.

III. RESULTS

The mission statement devised as a result of the planning stage is highlighted to have the following characteristics:

Product description: Electronic cigarette with rechargeable batteries and liquid nicotine mixture.

Benefit proposition: Reduces passive smoking and environment friendly.

Key business goals: Will readily replace common cigarette in market.

Primary market: 80 percent of middle age working class men belonging to various professions. 5-10 percent of women belonging to upper class.

Assumptions and constraints: Ambiguity regarding the new technology. Reluctance towards shifting to a newer version of cigarette. Lack of affordability by lower class.

All of the above inferences lead towards a consolidated mission statement which represented a rough sketch of the product. Based on the survey of market and customer interviews a number of key factors were identified. The results indicated that the consumption of the cigarette was about 2 to 3 packets a day for a regular smoker. Affordability was also a prime factor in determining which cigarette was purchased. Many of the smokers also emphasized on the aesthetics of the cigarette as they considered it a way of showing class and stature. After the interpretation of the raw data collected, the evolved metrics which highlight the needs of the customer contains information like

- E-cigarette will taste just like normal tobacco cigarette except that it will have no tobacco.
- It will look more like a cigarette than a machine. This will help quit smoking to help simulate smoking in chain smokers
- It will be affordable considering the fact that it can be refilled easily with nicotine cartridge.
- It will be environment friendly as water vapors will be emitted instead of smoke.
- It will be portable and easy to use.

The problem identification process revealed the following facts:

- The problem required water based nicotine liquid solution, atomized or vaporized, to be

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inhaled directly without actual tobacco usage

- The product should be rechargeable and allow for clean water vapor smoke emission to eliminate SHS dangers
- The product should look and feel exactly like cigarette to simulate smoking, aiding people who want to quit smoking
- Refilling of nicotine cartridges should not be a problem and each cartridge should be long lasting

The black box generated for the explanation of the working of an E-cigarette in order to decompose the problem efficiently is given in Fig. 1

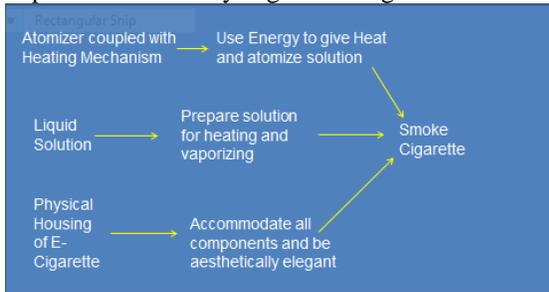


Fig. 1. Problem Decomposition Black Box

After the problem was decomposed into sub problems various concepts that aimed to provide solutions to the sub problems were organized into a Concept Combination tree to generate multiple concepts given in Fig. 2.

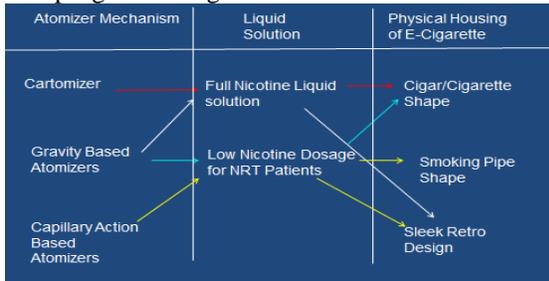


Fig. 2. Concept Combination Tree

The categories under which the table was classified were the sub functional parts representing the product in the black box. These categories were used as they gave a better understanding of how the concept being formulated will function. One fragment of each column is matched with the next one providing a complete concept of the product.

The combinations resulting from the table are not definite solutions and can thus be refined later to generate a better concept. For a better and more tangible concept the infeasible ideas were disregarded completely thus leaving only four possibilities for consideration.

The characteristics of the four concepts generated through the concept combination table are:

- Capillary Atomizer, Low Nicotine concentration, Modern Design (A)
- Gravity Atomizer, Low Nicotine concentration, Cigarette/Cigar (B)
- Capillary Atomizer, Full Nicotine concentration, Cigarette/Cigar (C)
- Capillary, Full Nicotine concentration, Modern Design (D)

These concepts were then examined with respect to a benchmarked reference product during concept screening to discard the less appealing concepts. The reference product has the following features: *Cartomizer, Full Nicotine, Cigarette /Cigar Shape*. In this process the four concepts were judged relative to the reference product under three categories, *Aesthetics, Smoking experience and Cost*. Fig. 3 shows how these concepts were rated and then ranked.

Selection Criteria	A	B	C	D
Aesthetics	+	0	0	+
Cost	-	0	+	0
Smoking Experience	0	-	+	-
Sum "+"	1	0	2	1
Sum "0"	1	2	1	1
Sum "-"	1	1	0	1
Net Score	0	-1	2	0
Rank	2	3	1	2

Fig. 3. Concept Screening

Concept A and D had LED indicator whereas concept C also had USB charging. From the screening matrix concept C came out to be the best having the highest score. On the other hand concept A and D had equal score. So A and D were combined to generate a new concept to make an atomizer offering full and Low Nicotine levels both as better option. Now concept C and concept AD were taken to the next step of Concept scoring.

- AD=Capillary, Full + Low Nicotine, Retro Design
- C=Capillary, Full + Low Nicotine, Cigarette/Cigar Shape

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Being left with only two concepts it was a lot easier to compare and select the best idea after taking into consideration five criterions under which these concepts were scored. A specific weightage was given to each criterion considering its importance in the target market as shown below.

- Cost 10%
- Aesthetics 30%
- Smoking Stimulus 40%
- LED Battery Notification 5%
- USB Charging 15%

A reference category was set in comparison to which the concepts were to be scored. The referencing is as follows:

- Much worse than Reference **1**
- Worse than Reference **3**
- Same as Reference **5**
- Better than Reference **7**
- Much Better than Reference **9**

The points awarded to the concepts for each criterion, is the discretion of the product developer. Following this step another matrix is generated which scores the concept thus giving one final solution. The concept scoring matrix that was generated is shown in Fig. 4

Criteria	Weightage	Concept AD		Concept C	
		Rating	Weighted Score	Rating	Weighted Score
Cost	10%	3	0.30	3	0.3
Aesthetics	30%	7	2.1	5	1.5
Smoking Stimulus	40%	3	1.2	9	3.6
USB Charging	15%	1	0.15	9	1.5
LED	5%	9	0.45	9	0.45
TOTALS	100%		4.2		7.35

Fig. 4. Concept Scoring

It is evident from the above scoring matrix that concept C is the most feasible one. This concept has capillary atomizer, provides full + low Nicotine levels, has a cigarette/cigar shape, USB charging as well as an LED indicator. When the final concept for the product has been selected by the various techniques discussed above concept testing was done via a survey and a sample of the survey is shown in Fig. 5

> Survey:

- Q. How often do you smoke?
- Q. Are you aware of the hazards of passive smoking... Do you feel guilty?
- > What our Product can offer you:
 - An electronic cigarette that produces water vapors instead of smoke, eliminating passive smoking, looks exactly like a real cigarette and allows you to control nicotine intake in vapor.
- > Q. If the product is priced accordingly given its resourcefulness, how likely would you shift to E-cigarettes?



Fig. 5. Customer survey for concept testing

Once the concept was tested and survey revealed positive feedback the product architecture was finalized and a schematic diagram of the product architecture was drawn in order to understand how the product functions by highlighting the flow of signals, material and energy in a product and is given:

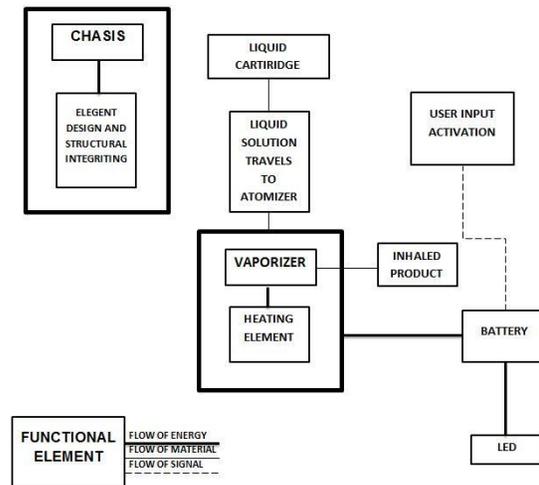


Fig. 6. Schematic of Product Architecture

IV. CONCLUSION

The technique discussed in the study illustrates the effectivity of an integrated product development structured technique in design of a product. The product design is based on customer needs which helps to identify the product specifications. These specifications are rendered as a problem which the product aims to solve. The concepts which focus on resolving the problem encountered by the customers

are generated by carefully decomposing the problem and analyzing every aspect. The final concept is nominated after ranking and scoring it with respect to each other and with some benchmarked reference product concept leaving no room for bias and leading to a rational and calculated decision about which concept is to be pursued for the product development cycle. It can be seen above that such a thorough approach to developing a product can be tedious but the results are fruitful considering that the aim of the whole process is to systematically reduce the chance of loss and maximize benefit of the developer or organization that is going to launch a product in the market. This approach is engineered to benefit from the dynamics of the market and uses customer feedback at every step of the process to ensure that the product is designed conforming to the needs of the customer.

V. REFERENCES

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