VALUE ENGINEERING TOOL FOR FRUGAL INNOVATION

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BIOGRAPHY

Nalini Nanrudaiyan has been with GE Global Research for the past five years. She is an electrical engineer by training and has got certified as an AVS very recently. She along with the team in GE global research, Bangalore is passionate about value engineering and is very keen in being part of spreading this culture across GE. One of the key initiatives the team in Global Research Bangalore is to get rid of the unstructured creative phase of value engineering, replace it with the more structured TRIZ problem solution technique, adapt and use some of its well proven TRIZ tools.

ABSTRACT

There are different forms of innovation models developed and used by companies, many of which are a top-down approach of structured innovation which is slow and expensive. Very recently it has been realized that in many cases, a bottoms-up approach would enable a cost effective, faster process of innovation which caters to the needs of the diverse global population better. Particularly there are enormous opportunities in developing countries utilizing frugal innovation. Frugal innovation aims at removing all unnecessary features from a product and reducing the cost; which, in turn, increases its market [1-3]. Frugal innovation is not about making things new, but making things better using fewer resources. In this paper we want to discuss the opportunities/ needs for frugal innovation, describe some of the frugal innovations

across the globe and explain how value engineering and TRIZ trimming tools can handle the non-essential or the harmful functions of a product that can lead to frugal innovation. The paper will make a case for use of value engineering and TRIZ in frugal innovation through a case study of medical devices for low and middle income countries. Statistics show that about 76% of medical devices are used by the 13% of the global population who are able to afford it [4]. In the past, this issue has been addressed by the "globalization" approach, which intended to remove the features of the high tech products for low income groups. Now, the mind-set of the medical device companies is changing as they have started analyzing the key challenges in these high tech products such as their power hungry nature and their inability to cope with heat, humidity and dust. GE is a company that sees the commercial potential of frugal innovation, and one of our most successful products to come out of this effort is "Lullaby baby warmer" which costs around one fourth of the cost of the device sold in US [5]. The tool described in this paper, enables private sector companies to make headway in the development and deployment of low cost medical devices which can help provide high technology health care to the vast majority of population in rural areas. In India, for example, 60% of population lives in rural areas. Value Engineering is a systematic approach to increase the value of the product by using an examination of the function, while TRIZ is a structured and algorithmic approach to solve any problem creatively. We believe the combination of these tools will enable frugal innovation that lays a pathway to reach the 'last mile' of the people.

INTRODUCTION:

The world-average ecological footprint in 2014 was 2.6 global hectares per person and the world-average bio-capacity is 1.7 global hectares per person. This leads to an ecological deficit of 1 global hectare per person. Projections show that we may need 3.9 earths if everyone lived like average Americans. With the current consumption rates some ecosystems will collapse even before the resource is completely depleted. There is a definite need to reduce our footprint either by consuming better, wiser and less or by producing more with less. Frugal innovation, which is nothing but functional solutions through fewer resources for the many who have little means, is not only a good solution but it is the need of the hour [6]. There are 4 of the 7 billion people on earth earn less than $2000 per year, and another 2 billion people earn less than $20,000 per year [7]. C K Prahalad and Allen Hammond described the benefits of creating viable products and services for this bottom of the pyramid consumers around 2002 [8]. Since then, the higher birth rate in these poorer nations has added to these benefits, and after 2007 big companies have been attracted to this huge emerging market opportunity. If we look at the Indian population, mostly they will not respond to frivolous innovation and they will buy tailor made goods. This knowledge about the acceptability of the product is very crucial because that is what is going to decide the emerging market. This has driven GE to take the first step into the frugal innovation; here is the brief explanation of how they did it.

1) Knowing the importance of affordable price
2) Knowing the customer

3) Creating a new value chain (described in the subsequent paragraphs below)

Knowing the customers is the key in the path to frugal innovation. When we are making a product for the economically disadvantaged population, knowledge about the customers and their living conditions are very important. The product most of the time has to be rugged and may be exposed to dust and high variations in ambient temperatures. These features which basically increase the acceptability of the product have to be obtained at low price. The natural engineering physical and engineering contradictions that is involved in such problems is quiet challenging and forces the engineers and scientists to work on breakthrough technologies that would push the limits the technology.

Innovation for the bottom of the pyramid customers are dictated by the affordable price. Few examples are the affordable sachet format, though the cost per unit of volume of the product is much higher. The affordability makes it attractive with the target customers and the high volumes of sale that can be pushed through the grocery shops are attractive for the companies. Major companies which appreciated this fact have driven frugal innovation by developing a model wherein affordability is the central issue. The challenge that is faced by these companies is to ensure the economic viability of the innovation and find out the best ways to sell the product to the target customers. A value chain is a set of activities that a firm operating in a specific industry performs in order to deliver a valuable product or service for the market. Big companies have exemplary value chains. When they have to offer a product for economically disadvantaged customers the value chain poses a serious hurdle. Let us take the example of GE Healthcare. It has traditionally been supplying high-end medical diagnostic equipment to major hospitals, so the value chain used for those customers is very different. To reach out to the doctors and the medical clinics in the countryside, GE developed a more appropriate channel; it tied up with the State Bank of India (SBI) which had a high penetration of rural markets, to provide no-interest loans for rural doctors. In addition, salespeople carefully explained to the rural doctors how the device would pay for itself within 2 years by considering a certain number of ECG reports at 20 cents per patient. This is just one example of the effort required to win the trust and credibility of the targeted segment.

VE JOBPLAN FOR FRUGAL INNOVATION:

PROJECT SELECTION:

Ideally value engineering (VE) can be performed on anything that has a function. But generally the key question is to find which would give greater return for the investment. Here for frugal innovation we need to address the needs of the financially disadvantaged population. We have to take the affordable price as the center point and also list the functions that would enable the acceptability of the product by these target customers and assign them higher weight of importance among the rest of the criteria. Some of the key criteria that should be considered in deciding whether it is worth doing VE are given below.

Components			Weightages	Costs
Hand	Holds handle	Auxiliary functions	1	0
	Moves handle	Auxiliary functions	1	
Tooth brush	Disolves paste	Basic function	3	8 (100%)
Handle	Holds base	Auxiliary functions	1	1.6
	Moves base	Auxiliary functions	1	1.5
	Informs person	Additional functions	2	0.1
Brush	Distributes paste	Additional functions	2	0.9
	Removes dirt	Basic function	3	1.5
Base	Holds brush	Auxiliary function	1	1.2
	Moves brush	Auxiliary function	2	1.2

Table 1: Tooth brush - components and functions

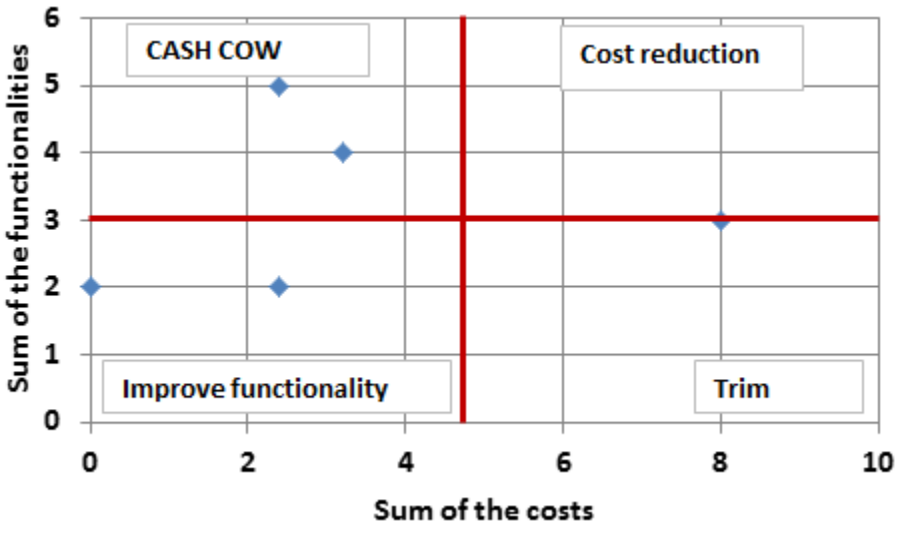

Figure 1: Value chart – product improvement strategy

1) Sales forecast of at least three years of the existing product and for the proposed frugal product

2) For each component or the part of the product, the sum of functionalities and the sum of cost are calculated. The sum of functionalities is calculated on base of the interactions, whether they are basic or additional or auxiliary and they are allotted weightages 3 for basic, 2 for additional and 1 for auxiliary functions. Table 1 describes the key functions of the various components of the tooth brush example and figure 1 shows the plot of sum of the functionalities vs sum of the costs. There are four sections in the figure and they define what improvement strategy shall be used. If we have more points in the lower half of the above graph it is a potential candidate for VE for frugal innovation.

3) Knowledge about the customer requirements and detailed customer analysis has to be done prior to the project. We should also list down the criteria and their weight of importance in decreasing order. Once we have brainstormed and have the set of idea, these ideas can be ranked based on these criteria and its importance. This same process should be used for evaluating projects in the various other categories such as process studies, procedure studies and so on.

Frugal innovation is all about delivering the essential functions and removing or trimming the non-essential or aesthetic functions that would make it affordable to the people in the bottom of the pyramid. Let us take a specific problem and try to use the VAVE and TRIZ tools to come up with affordable solution. There are a few key factors to keep in mind before starting to use the tools, which includes:

1) Understand the customers and their needs
2) Understand the root problem and don't get biased with what already exists, doing this we can truly bring technology to masses.
3) Remember the key objective is to come up with a simple, localized, affordable solution that has potential to have huge social impact
4) Empathy is a key driver
5) Entrepreneurial design for extreme affordability- design services and products for the needed population

A detail description of the problem is given in the information phase. We describe how the process would have worked if it had been applied on baby warmer.

INFORMATION PHASE:

A brief description of the problem is given below: Every-year around 4 million out of the 20 million babies born in India die battling hyperthermia, due to an inability to regulate the body temperature [9]. The pre-mature babies are generally kept on incubators to help them fight against these conditions during the initial stages of their life. But the challenge is in countries like India, where only 13% of low income women mostly in rural areas give birth in a health

facility, and only 1 in 7 home births are assisted by a trained professional [10-11]. Very rarely do these rural health care facilities have sophisticated incubators which can cost as high as $12000 USD. The town hospitals which have these facilities are at far off places and hardly affordable. The objective is to design and develop affordable and economically viable baby warmer. Other input that needs to be considered includes: input power requirement, simple enough for mother or mid-wife to use, ultra-low cost, and meet IEC requirements and health care regulatory requirements. We want to describe two different approaches here, one is the approach using Value Engineering alone (approach 1) and another is the approach using the hybrid tool, Value Engineering and the TRIZ (approach 2).

APPROACH-1:

FUNCTION ANALYSIS PHASE:

The baby warmer essentially consists of a heater element, temperature sensor, temperature indicator, baby tray or table, light and the device is also helped with resuscitation (airway management, suction, etc) options. The approach that is suggested is to look at the components from the point of view of what they do rather than what they are. The objective is that it would help us think about alternate ways of doing the same function. The function list, type and cost are populated in the function worksheet. The type of the function is very critical because this is going to tell us whether they are the main functions or auxiliary functions or harmful functions. We can think about retaining the main functions and trim the auxiliary or the aesthetic or harmful functions. The next step is to come out with the FAST diagram.

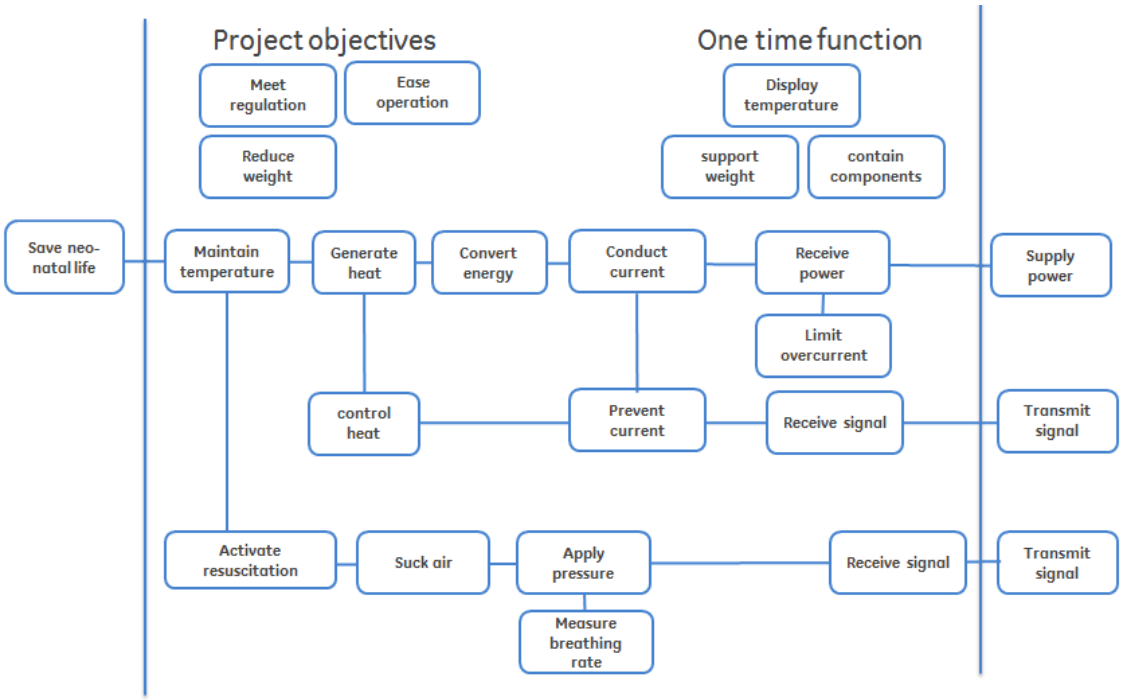

Figure 2: FAST diagram for the GE baby warmer

The cost function matrix helped us to determine the following functions to be the most cost involving functions.

1) Generate heat
2) Control heat
3) Maintain temperature

IDEA GENERATION PHASE:

Organizations adapt to different approach and come out with radically different approach and solutions to problems depending on cost target, value chain and experience levels. With the challenging cost target and customer understanding we have to look into alternate ways of doing the above cost involved functions. The following were the motivation of the open brain storming

1) Not to get biased with the existing solutions
2) Knowing the customer well
3) Product knowledge, standards and regulation requirements
4) Push the limits of the technology, challenge the conventional ways of doing things

One of the things that we understood was efficient fast heating is one of the key requirements. The set of solutions typically an open brainstorming would lead to are listed below:

1) Uniform heating
2) Fast heating
3) Faster warmup
4) Reduced power consumption during the start-up and during operation.
5) Adjusting the bed tilting angle
6) Simpler controller electronics

Incorporation of one of the solution or a combination of these solutions would enable cost savings from reliable operation and reduced power consumption. I want to cite here this example of Lullaby warmer prime product coming from our India R&D center [10-11]. The success story of this product is an inspiration to work on methods to measurably reduce cost and improve, access and quality of health care.

APPROACH - 2:

While the solutions like “Lullaby” works for healthcare centers on budget, it still needs electricity to run. But go further down the population pyramid and the problems become more complex. Women in villages give birth at home and have little access to basic healthcare or electricity. For them, keeping babies warm means wrapping them in layers of fabric and hot water bottles or putting them under bare light bulbs. Many of them don’t survive. This understanding of the environment of the customers poses additional requirement of a product that would work in the absence of electricity. This kind of requirement clearly needs a re-think of the problem, an out of the box solution. A brief description on how a TRIZ tool can be

instrumental in coming out with such an out of the box ideas solving this critical problem is given below.

TRIZ TOOLS:

Thinking out of the box is the necessity for solving the key problems of the emerging market. For this problem of the baby warmer, among all the competing TRIZ tools, function oriented search is more useful. Function-Oriented Search (FOS) [12] has become one of the most powerful TRIZ-based problem solving tools in the world today. The main idea of FOS is bringing an already existing technology from a very remote area of science and engineering as a solution to the problem in the initial area that needs an innovation. The specific tools of FOS are function generalization, function-leading area identification, and global knowledge network. Let me illustrate this approach and its use for this baby warmer solution. Let me re-look at the problem again with this additional requirement.

- Goal – to protect neo-natal from hyperthermia or cold stress with a product that is easy to operate, doesn't need continuous electrical input and cost <$100.
- Target main parameter values (MPV) – Maintains the desired temperature of 37 degrees Celsius (98.6 F) for up to six hours (maintain effectiveness), low heat transfer co-efficient material to maintain the temperature constant for long time, rate of heating should be faster, less power consumption, cost, safety and reliability.
- Best product on the market – Baby warmer with uniform heating, faster heating, less power consumption, needs electricity and ease of operation, but costly.

FUNCTION ORIENTED SEARCH:

We did the function oriented search for this problem and propose the following set of questions to seek the answer for this problem.

- Specific Function – to heat the surrounding.
- Initial engineering/scientific area – Thermodynamics, selection of material with low heat transfer co-efficient of material, material science and exothermic chemical reaction.
- Generalized function - to maintain the heat constant.
- Function leading area of engineering (one of a kind) – Freezing is almost always an exothermic process, meaning that as liquid changes into solid, heat and pressure is released. Target MPVs are same but the major constraints are different. Freezing generally is expected to happen faster, but here the material should emit heat continuously. The material should have very low heat transfer co-efficient. Exothermic reactions can be used for everyday purposes.
- Expertise from the global knowledge network - For example, hand warmers and self-heating cans for drinks (such as coffee) use exothermic reactions.
- Selected function oriented search derived solution/technology – Phase transition material with low heat transfer co-efficient.
- Function derived solution action principle – phase transition material not used in bulk but in small quantity in array of pouches in the heating bag, this enables the uniform heating for duration specified.

- The function derived solution substantiation is a time consuming process.

The solution suggests looking into the possibility of using a phase transition material that is put up in small array of pouches in the bag. Scientist now can look into the material to be chosen based on the other facts like: the material should be converted to liquid faster with less energy input; it should maintain the temperature of the surrounding constant and for long time. Coincidentally, an acclaimed product based on this technology solution- the Embrace infant warmer developed by Embrace innovations has been in use for a few years now. [13]. Typically the strength of FOS can help find promising technologies/ solutions in a fairly short time period, but sometimes the adaptation of the solution suggested may create a new adaptation problem that has to be solved as well. In addition to the technical substantiation there are other aspects of the idea substantiation

- Business substantiation - business impact justification, preliminary business case, and risk factors assessment, market acceptability evaluation, etc.
- Intellectual Property (IP) substantiation - preliminary evaluation of technical novelty of the idea, recommended IP protection strategies, etc.
- Design substantiation - preliminary design, industrial design, etc.
- Safety substantiation - FDA, safety regulations, etc.

JOB FUNCTION OF APPROACH _2:

The brainstorming phase of the usual VAVE job plan is unstructured and has other disadvantages like the idea generation is limited to the knowledge and expertise level of the team in the room. The approach we are suggesting here is to have a structured brainstorming using TRIZ tools. With very challenging problems having physical and engineering contradictions, the unstructured brain storming has to be streamlined or focused with solution indicators which is what the TRIZ tools does. Here, we explain the job function of the approach-2 which is the job plan that has evolved with brainstorming session replaced with the TRIZ tools. Figure 3 shows the job plan of the typical VAVE + TRIZ workshop.

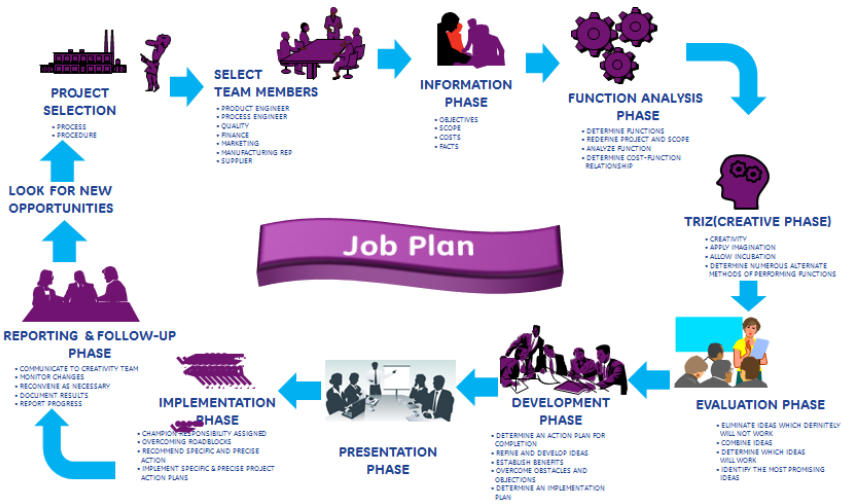

Figure 3: VAVE+TRIZ job plan

Here is brief of the agenda and experience of one of the very first workshops using this hybrid problem solving technique VAVE and TRIZ. We started with the problem definition and the function analysis on the first day of the workshop. By the end of the first day we were ready with the FAST diagram, we had a short tutorial session on TRIZ basics. TRIZ methods have been developed over the course of the 60 years of TRIZ research and have been organized in many different ways. Some of these are analytic methods such as:

- The Ideal final result and ideality
- Function modeling, analysis and trimming and
- Locating the zones of conflict

Some are more prescriptive such as:

- The 40 inventive principles of problem solving
- The separation principles
- Laws of technical evolution and technology forecasting and
- 76 standard solutions

We introduced the different problem solving tools like S curve, 9 boxes technique, function oriented search and handling contradictions. If the nature of the problem can afford to have out of the box solutions then tools like su-field model can be explored.

The second day of the workshop we started with the cost matrix analysis and found the critical path or the cost involved functions to concentrate. Once we know the functions we need to work on, we used the function oriented approach to come out with the suggestions or pointers to the solutions. The pointers were then suggested to the team to brainstorm on the basis of that. We had couple of engineering contradictions and one physical contradiction. We extracted the general solution what TRIZ suggested and brainstorming was focused around the pointers. The rest of the workshop we spent on the problem evolution and writing the proposal. The advantage which TRIZ brings to the table is the solution pointers; these are the solutions that worked already. So the basic doubt about feasibility is ruled out and the four steps approach of converting the specific problem to general problem and getting a general solution and then converting it to the specific solution forces the user to overcome inherent psychological bias that is typically the foundation of psychological ideation techniques.

CONCLUSIONS:

Frugal innovation attaining maximum value with minimal resources is the need of the hour. Companies like GE have understood the huge potential of the emerging market in developing countries like India. The paper describes a fusion of the function thinking of VAVE and the solution adaptation from other industries and their adaptation to the specific problem can be shortest route to come out with out of the box solution to the extreme affordability problems.

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