EXPLORING FRUGAL ENGINEERING PROCESS TO BECOME MORE REGULATED, RELIABLE AND SAFE

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ABSTRACT

Frugal Engineering or Frugal Innovation is the process of reducing the complexity and cost of commodity and its production. Usually this refers to removing non-essential features and accordingly the production activities from a long-lasting commodity. However there is likelihood that this process may impact by induce the irregularity, unreliability, and develop the feeling of insecurity, inferiority and losing the aesthetic appearance of the commodity. In this paper attempt is made to explore frugal engineering process to become more regulatory, systematic and safe by analyzing the process and deploying a few recognized techniques.

Keywords: Frugal, Jugaad, Innovation, System-Engineering, Bop, Value-Engineering, Value-Analysis, VE, VA, FE

INTRODUCTION:

About Frugal Engineering

According to ATKearney (2012) as rising commodity prices, unrelenting competition, and price-sensitive customers squeeze profits, more manufacturers are turning to frugal re-engineering to reduce costs and improve margins. Frugal re-engineering has the potential to drive year-on-year cost saving of between 7 and 12 percent.

Khanna A (2014) stated that The Frugal Engineering (FE) philosophy involves breaking up and rebuilding a cycle that culminates in a simpler, more robust, easier-to-handle final process and

cost-effective final product. Rising costs have rendered healthcare less affordable even as new taxes on devices in the USA increase the Original Equipment Manufacturers' (OEMs') cost of device development. To compensate for the increasing costs, system inefficiencies need to be eliminated.

FE offers one such avenue for driving this improvement in healthcare. FE enables lower cost of product development; lower Cost of Goods Sold (COGS) through Low Cost Country (LCC) sourcing, and a larger focus on the unmet needs of the clients.

FE has been leveraged by several industries to reduce overheads and develop products that meet the critical-to-quality requirements, by eliminating requirements that are not must-haves.

As per Dan O'Neill(2012) FE is a concept that has emerged in the last few years to describe how the product / service (hereafter, product) development process must be completely rethought and rebuilt in order to design, develop and deliver innovative solutions to customers at the Base-of-the-Pyramid (BOP). Instead of attempting to re-engineer products originally designed for wealthier markets, FE targets development of products that begin with the BOP population as the primary target customer. BOP customers have unique needs that must drive the product innovation process.

FE can be thought of as engineering under constraints dictated by these needs, not the least of which is "extreme affordability," the requirement that products be affordable for customers earning a dollar or two a day. Product purchases must also occur within the cash flows of those customers, who typically have seasonal, uneven cash flows, but who are also willing to save for purchases and/or finance them through various forms of microfinance.

Add to extreme affordability the fact that BOP products often have to operate in extreme conditions with little maintenance, waste or inefficiency, and must be serviceable in a manner that is as equally affordable as the original price. Meanwhile, product developers have realized that BOP customers have the same expectations of quality and desirability that customers have in all markets.

In sum, engineers must design and build high quality, feature-appropriate technologies and products that are affordable, require low maintenance, reduce waste and inefficiency, are designed with the socio-ecological context of the customer in mind, and can be purchased by the customer within the context of their income and cash flow situation.

These constraints lead to a complete rethinking of the engineering processes used to develop BOP products. This may result in a rethinking of design processes for the developed world as well.

Understanding Jugaad

According to Nimmi-Rangaswamy (2013) Jugaad is a many-splendored conceptual tool in popular culture, business strategy research and journalistic writing. It is regarded as the latest trend in strategic management circles, an example of bottom-of-the-pyramid (BOP) disruptive innovation, a chaotic yet successful work around resource constraints.

Frugal Innovation defines Jugaad as an innovative and improvised solution born from ingenuity and cleverness, equating it to similar concepts in other countries, including "D-I-Y" (do it yourself) in the United States. At the same time, they are known to be unregulated and often unsafe. Today, this idea of making do has been extended as a business philosophy, capturing Indian creativity alongside the need to navigate gray/illegal areas in order to get things done in a resource-constrained context.

The concept of Jugaad from a BOP perspective is not as a quick fix but a new framework to an efficient and effective way of survival, sometimes coined as frugal innovation.

Jugaad is tied deeply to the local limitations preventing access to "formal" goods, and also hindering traditional forms of innovation. Social processes characterizing Jugaad reside at the intersection of technology consumption, resource constraints, and cultural production specific to low-income communities.

FRUGAL ENGINEERING (FE) PROSPECTS

As rising commodity prices, unrelenting competition and price-sensitive customers squeeze profits, more manufacturers are turning to frugal re-engineering to reduce costs and improve margins. Most manufacturers know about this technology – the concept of developing innovative, no-frills products at the lowest cost possible.

FE is structured, sustainable process of continually redesigning the product to cut costs. Cost-effective continual re-engineering (or continuous improvement in manufacturing) of a product is the essence of FE.

"FE – Achieving More with Fewer Resources" Resources of the Mother Earth are dwindling at an alarming rate, with over-consumption, wastage and of course, genuine use as well, by the ever increasing population. To face such a challenge, FE appears as a mantra to be adapted in all walks of human activity to retain the world in sustainable form.

Following factors are contributing towards generating the demand for FE

- Scientific Temper
- Implementation
- Improved services
- Better Governance
- District level Development
- Maintenance
- Dignity of Labor
- Security & Safety
- Alternate energy
- Process Re-engineering

ATKearney (2012) explained the frugal re-engineering builds on the concepts of value analysis, value engineering (VAVE). It encompasses the strategic imperatives of an empowered organization supported by processes, metrics, tools and systems. It enables companies to continually reduce costs in structured manner.

NEED / BENEFITS OF FE

Margin pressures due to rise in commodity, manpower and power costs, besides intense competition, are not new to the manufacturing industry. However, the measures required to be taken by the industry to placate these challenges on an ongoing basis may need to be directed in areas related to design optimization and FE, where results become visible only over a relatively longer time horizon. This may require the industry players to incur greater investments; however, the longer term benefits and resultant structural changes could alter the automotive design paradigm, change the cost drivers and provide greater value to customers.

Frugal innovation or FE is the process of reducing the complexity and cost of a good and its production. Usually this refers to removing nonessential features from a durable good.

"FE" was coined by Carlos Ghosn, the joint chief of Renault and Nissan, who stated, "FE is achieving more with fewer resources.

- Lackluster growth and deleveraging in developed economies will increase demands for frugal products and services and frugal innovation processes.
- Environmental constraints around climate, energy, water and other resources will increase demands for more frugal models of production and consumption.
- Caring for rapidly ageing societies will require completely new approaches to health and social care, including the radical rethinking of business models and value chains that is apparent in some examples of successful frugal innovation.
- Today's fastest growing markets are in developing and emerging economies where demand for frugal products and services is naturally high.
- New technology platforms are drastically reducing the cost of some forms of innovation, which is creating huge new opportunities for frugal innovators, particularly in services.

Frugal innovation responds to limitations in resources, whether financial, material or institutional, and turns these constraints into an advantage. Through minimizing the use of resources in development, production and delivery, or by leveraging them in new ways, frugal

innovation results in dramatically lower–cost products and services. However FE benefits coming with its own limitations.

LIMITATIONS OF FE

Some of the perceived confines of FE are as follows

- Lower-costs product and services means it must be inferior in quality and appearance
- Frugal engineered products and services are treated as unregulated, unreliable and unsafe
- Can work in 'well-defined products', e.g. cars
- Less likely in products that are in early stage of product cycle
- Most breakthrough innovations have roots in defense & related funding
- Best brains in the world are busy solving problems of the rich who do not have problems to solve
- As a result complex problems of the poor do not get the right talent; It takes time to change this paradigm

It is also an opportunity for FE

FE PROCESS ANALYSIS

FE process is analyzed by comparing the traditional innovation model with FE model.

Traditional Models Create Stagnation and Kill Innovations

Traditional top-down approaches are less effective in narrowing the gap between the 'branded' product and large number of customers who uses product but may not afford the price; these models have typical characteristics as

- Firms in high income countries develop high value products
- These products adapted, pared down for low-income markets
- Linear relationship between products and base of scientific knowledge

Traditional Models Create Stagnation and Kill Innovations, and there is a risk to inducing the functional defects while carrying out any improvised modifications in the product design.

Proposed FE Model

As per Khanna A (2014) FE involves the breaking up and rebuilding cycle that culminates in a final product that equals more expensive, complex equivalents. In recent times, Value Engineering (VE) has gained prominence as a methodology adopted by manufacturers for developing innovative and cost-effective products. VE is a systematic approach aimed at obtaining the desired functions of a product at minimum cost, providing maximum value while maintaining or enhancing performance, quality, reliability, and safety, and adhering to environmental norms.

Top-down technology with bottoms-up adoption strategy for FE model with following considerations

- Rising economies – high volume, but low unit value
- Require FE to meet demand
- FE as reverse innovation
- New processes, not products, developed in and for low-income markets, then go back to high-income markets

Proposed steps in FE Model

It is proposed to adopt systematic steps in FE model to overcome the limitations of FE to certain degree. These steps are somewhat similar to the recognized techniques such as software engineering (SE). The steps proposed are interlinked i.e. output of prior step is output of the next step.

- **Benchmarking**

S. Rajadurai et. al. (2014) focused on 'baselining' or benchmarking; according to them FE, the science of breaking up complex engineering process into the basic components and then re-building each component in the most economical manner to achieve a simpler, more robust and easier to handle final product. Benchmarking process is a pre-requisite for Value Analysis and Value Engineering (VA/VE).

The decade of 2010s is the Decade of FE as the first decade of 2000 is the decade of Globalization. FE is necessary to demonstrate the competitive advantage and the simplicity of a product.

Benchmarking is a technique followed to understand the status of a product or process which is in practice and can be used to develop or improve the value of it.

Benchmarking leads to a deep understanding of the processes and skills that create superior performance. Without this understanding, little benefit is achieved from product engineering. It is a method which helps to compare various processes or product to improve performance and value.

There are many reasons why we should actively consider benchmarking while proceeding for best product development. No product is the best at every element considered. There is a need to search for good, promising, practical and better if not the best product always. The best performer needs to be captured, transferred and adopted throughout the development stage though it involves series of hurdles. Benchmarking exists to overcome the obstacles in a disciplined way.

Benchmarking technique can be broadly classified as process benchmarking, performance benchmarking and strategic benchmarking. The requirement of FE for the dynamic and challenging technical world is clearly defined with various elements involved. Benchmarking is first step discussed and differentiated from Technical Competitive Analysis and Value Proposition.

The expected outcome of this process step is exact status of current (before FE) processes and corresponding performances of existing product.

- **Gap Analysis**

The traditional technique for identifying the gap between ‘AS IS’ and ‘TO BE’ is proposed to apply for gap analysis. The earlier step of benchmarking provides input to this step as ‘AS IS’ status.

To determine the 'TO BE' status, as per Dan O'Neill(2012) Instead of features being engineered out of products originally targeted at higher priced markets, FE begins with a clean sheet and targets high quality, durable, affordable products with just the right need-feature-benefit configuration required by the BOP customer.

Products must generate a significant return for the customer. For instance, they need to reduce labor and land requirements in agricultural economies. Because they are low price and low margin, products must employ few assets, which, paradoxically, can result in a high return on equity for the investor.

The result is a requirement that engineers developing BOP products have a deep understanding of the unique requirements of the BOP customer, and that they work to an engineering process that is qualitatively different than that employed for developing most products today. In practice, this means that product development teams must evolve and embrace interdisciplinary team structures that include members who are expert in the needs of people living at the BOP, working side-by-side with engineers, manufacturers, designers and business members schooled in ways of doing business in specific cultural settings.

Differentiating the features in terms of '**Wants'** (luxury) and '**Needs'** (essential) is critical for step.

- **Feature removal / modification list**

The non-essential (or luxury) features from the product or processes from the services can be identified from the gap-analysis output. Features removal or modification finalized list need to be further analyzed for measuring the impact on the performance.

Traceability Matrix: Traceability Matrix (TM) is useful technique proposed in which the list of identified features tabulated and linked with the corresponding elements (of the product) that is going to be affected by each removal or modification.

- **Impact Analysis**

Using TM the precise impacted elements can be identified and can be focused for the changes.

Risk Analysis: Risk Analysis (RA) is a technique proposed, in which the probable risk (e.g. non-functioning / mal-functioning or performance degrade) on business activities analyzed for final decision making. i. e. commercially is it feasible to remove / modify the features in the product.

- **Estimation and Planning**

Systematic road-map can be prepared including the activity details needed for removal / modifications of features in the product. Once scope of activities is determined the estimation in terms of time, cost and effort is easy required for planning and scheduling the activities and resource planning.

- **Implementation and piloting**

While implementing the FE product piloting is recommended to ensure there is no adverse effect on the business functioning. Careful testing and monitoring preferred before release of FE product for implementation.

During FE all additional 'luxury' features are removed (probably features like 'help' might be removed as excess), hence while using such product ensuring sufficient user training is expected.

- **Other factors to be considered**

Khanna A. et al (2014) explained **FE for Marketed Products** as Given the synergies between FE and VE, the latter can serve as the ideal framework around which the ideas and elements of FE can be built. It is indeed felt that this synergy can be exploited very effectively to re-engineer existing or marketed products. Activities related to applying VE to marketed products that can be influenced by the frugal approach include:

- Market segmentation, customer profiling, and target product costing
- Material definitions and manufacturing processes consistent with the local needs
- Estimation of Function Worth – the lowest cost of accomplishing a function
- De-featuring by discontinuing a few related functions that may not be relevant to the target market

- Identifying alternative means of function accomplishment based on highly innovative solutions from a frugal standpoint
- Evaluation of alternatives against parameters that promote the Frugal approach, while allotting higher weightage to such parameters

They elaborated further **FE for New Product Development** as the benefits of following Frugal Engineering to develop products in emerging markets are well acknowledged. Developed markets can also benefit by applying the Frugal approach to areas of development that encompass the total product lifecycle, including initial investigation and planning, design, manufacturing, sourcing, operation, and sustenance. Indeed, many of the approaches discussed in the 'Value Engineering as the framework for Frugal Engineering' can also apply to a product development scenario.

According to Khanna A. et al (2014) there is a necessity to **Promote a FE Mindset.** Hence regardless of the product development scenario and the market to which it is applied, FE is the key to creating value by controlling costs and developing innovative solutions.

Core teams should be formally trained or educated in the FE discipline. Starting at the front end of product development, marketing should clearly identify Critical to Quality (CTQ) requirements while gathering important Voice of Customers (VoC) insights. Linking this VoC learning to unmet customer needs ensures that customer wants can be differentiated and addressed separately. Segmenting the market, selecting the target segments and positioning Frugal Engineered products is the responsibility of marketing teams, and should be done before product development commences.

At the very early stages of the product development itself, a decision needs to be made on implementing only those features and functionality that are required and valued in the target market. 'Cost avoidance' being a key tenet of FE, this would also preempt huge capital investments on the associated resource skills and specialized processes.

Design and development can be carried out at a low cost location that offers abundant talent with minimal language and cultural barriers. During the design phase, the engineering team can look

at adapting the design to the manufacturing geography and also identify cost effective components and materials sourced extensively from LCC.

Aggressive product cost targets, another key requirement of FE, can be met by the engineering teams focusing on the principles of VE and DFM, through part and/or feature level standardizations, part cost revisits, and target costing.

Simplification of manufacturing and downstream processes can be achieved through simplified designs with reduced part count, compacting design, and metal-plastic conversion which can also result in lower product weight and space claim. Adopting principles of lean manufacturing can also promote FE through manufacturing process optimization.

Core teams also need to assess manufacturing at the nearest low cost plant. The cost of logistics should be built into the business case for the final choice of such a location.

By adopting Frugal Engineering for product development, OEMs can benefit from lower product development costs. The resulting savings can be used to compensate for other cost contributors such as inflation, labor cost, government taxes and others, while boosting profitability and helping fund future programs.

OTHER APPROACHES

Singh SK et al (2012) in their paper 'Frugal Innovation: Learning from Social Entrepreneurs in India' identified **seven approaches** to innovation as

1. Economies f scale
2. Smarter use f people
3. Technological innovation
4. Scaling up
5. Finding a niche
6. Tiered pricing
7. Alternative source of revenue

To achieve the drastically lower prices that emerging markets require companies must be open to rethinking all aspects of the product.

They concluded as FE requires that companies be open to organizational innovation, as well.

Three areas are identified as important:

a. Formation of Cross-functional teams: There tends to be little coordination between functions without an explicit effort from top management, which must either create a new structure for the team or use brute force to encourage communication. That is happening more often, but it's still more the exception than the rule. In mature industries, companies are optimized for their main customers. For emerging markets, a different organizational approach is required, both within and outside the organization.

b. A nontraditional supply chain: When reducing costs, most companies focus on getting better prices from their suppliers. The problem with this approach is that the reductions can go only so far; cut too deep and the suppliers' margins are eliminated. Frugal engineering instead treats the suppliers as an extension of the enterprise. Such a lean manufacturing approach is not new, of course. But FE pushes the concept further, by demanding new levels of cost transparency, and by requiring that suppliers grant genuine authority to their representatives on the core product team.

A frugal development team must look beyond the usual, approved list of suppliers. The targets in frugal engineering projects are often so tight that conventional suppliers are unlikely to be able to meet the requirements for cost, quality, and timeliness of delivery.

At the same time, suppliers step up and become more involved in development projects.

Traditionally, original equipment manufacturers (OEMs) dictate their requirements to suppliers; the suppliers ask few questions and compete on price. In frugal engineering, the game is different. OEMs and suppliers team up to set cost targets and a cost structure. Rather than focus on individual components, they work together to optimize entire systems.

c. Top-down support: Nothing is more important to frugal engineering than commitment from the top - and not just from suppliers.

FE DRIVERS

Some of the factors that drive FE are

- Multidisciplinary
- Collaborative
- Disruptive
- Generational Change vs. Incremental Change
- Durable vs. Disposable
- Need vs. Demand
- Nature as Nurture
- Locally Relevant
- Globally Connected and Competitive
- Focus at the Edge

INFLUENCES ON FE DEVELOPMENT

As stated by Kirsten B (2012) following are the influences on development of FE

	1960s to 1980s	**1980s to 2000s**	**2000s to 2010s**	**2010s onwards**
Social movements	Appropriate technology	Sustainable development	Private sector–led development	Ethical capitalism
Globalization of science, technology and innovation	–Technology transfer from developed to developing world	–Growing distribution of technology design and production with the rise of the East Asian Tigers –The Internet	–Increasingly networked global innovation system as multinationals explore new locations for R&D –Cheap connectivity	–Interdependent, globally segmented innovation by Multinationals. Two (or more) way flow of ideas –Widespread digital platforms for collaboration
Innovation management	–Systems analysis	–Lean manufacturing	–Open innovation –Design thinking	–Frugal innovation

schools of thought		–User–led innovation	–Frugal engineering	
Emerging economy markets	Peripheral	Emergent	Recognized – the fortune at the bottom of the pyramid	Towards the centre of gravity

(Table-1: Influences on FE development)

CONCLUSION:

As stated by Dan O'Neill(2012) FE is a concept that has emerged over the last few years to describe the new way in which we must think about the engineering processes, and how we need to rethink ways to develop / modify products and services for demanding BOP (Bottom-Of-Pyramid) customers and environments.

Engineering is solving technological problems under constraints, so adding a "frugality" constraint makes sense and, in fact, creates products that fit the BOP challenge set. The term Concurrent Engineering (CE), which was popular during the 1990s, consisted of a multi-disciplinary team working together to solve engineering problems. Frugal Engineering is the modern-day version of CE applied to BOP problems and including all of the disciplines.

Differentiating the requirements between 'Wants' (luxury) and 'Needs' (essential) and implement the changes systematically are the key success factors to make FE process more regulated, reliable and safe.

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TABLES:

1. (Table-1: Influences on FE development)