Design for human energy
A design methodology that incorporate traditional manufacturing techniques

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Global concerns towards environment have been consistently increasing. The whole world is moving towards the energy conservation and use of alternative natural methods in every walk of life. Simultaneously, there has been an enormous value, demand and a preference which is growing for niche hand crafted products. The whole perception towards the handmade product and environment friendly products is fast changing and is looked at as almost divine, be it hand woven Japanese silk or handcrafted Swiss wrist watches. These products have attained a special status catering to very niche clientele. One can clearly connect the vacuum of availing the natural human resources/expertise and at the same time produce product of very high value, also contributing in a small way to the green revolution. In this paper, it proposes a design methodology wherein products are strategically designed in such way that the human energy and traditional knowledge / skills are leveraged to develop new generation of sustainable product.

Keywords: Sustainable design, Design for human energy (DHE), Design methodology

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Contextual background
Tremendous amount of research has been undertaken in the design methodologies by the design schools in West and the way new product is developed. India is also looking at framing the national design policy, clearly showing the importance of establishing design research. The concern for nature by the design and manufacturing engineers is evident in the forms of design for manufacturing, design for environment, green product development, eco-friendly manufacturing techniques, etc. Most these researchers tend to either suggest to use eco-friendly natural materials are biodegradable substances, and also advices to use recyclable materials. Some of the researchers also point out green manufacturing techniques which are less polluting and elimination of waste through the production process. In the past attempts have also been made to place the climate control mechanisms like the Kyoto Protocol, with objectives to establish a legally binding international agreement, whereby all the participating nations commit themselves to tackling the issue of global warming and greenhouse gas emissions. The Copenhagen climate summit introduces a new phenomenon in international relation through a confrontation between the main polluting countries and the greatest potential victims of climate change. The low lying island countries that face being wiped off the map by rising seas brought about by warmer world are continuously demanding for negotiations of new global deals.

On the other hand, there is a growing demand (exports of INR 8,343 crores last year, compared to 1,970 crores, recorded a decade ago) for the handmade in India tag catering people who are highly conscious of the perceptional emotional value. According to the development commissioner handicraft currently India is producing handicrafts worth about INR 30,000 crore, of which 11,000 crores were exported. The country’s handicraft exports accounted for 37 % of the total production. India has about 1.25 crore artisan energy. The sector even provides a high ratio of value addition, and has emerged as one of the major sources of foreign exchange earnings for India. Besides this, Indian handicrafts are much sought after the world over, and form an important export commodity of India. Looking at the present scenario the present handicraft
tradition of India is a perfect paradigm of integration between the traditional designs and modern techniques. India is the world repository of traditional knowledge and skills which are passed on from generations and now promises to craft the high value products by leveraging the human energy and literally no machines, which is a paradigm shift in the alternative manufacturing systems. The human energy based manufacturing would be instrumental in addressing most of the eco-production concerns.

Objectives of study

This research paper provides a design methodology where the traditional human energy in the form of traditional manufacturing knowledge and skills are focal considerations. The methodology also suggests the possible consideration during the conventional materials and the manufacturing process selection steps of the design cycle. The above design methodology is put in to validation by application in the development of new niche product family.

Conventional product design process

Product design process is a process of giving a something new after understanding the need and the priority of the market. The newness can be brought forward by a dream of ideas/concepts. Design also provides the psychological positioning as against the competitions and also fulfills the desired functional requirements (Fig. 1).

All the goods and services that are around us are the result of a development process. Product development is a conversion process where market requirements are converted into some concrete product ideas that we experience. It is the basic need of every manufacturing company to design and develop new and innovative products to cater to the needs and expectations of the customers. During product design, designer has to bear in mind the customer requirements, available resources, possible implications on company policies, etc. It is therefore obvious that product design is at the core of the development and growth of every manufacturing system. But one should bear in mind that design and development of new product is expensive and risky. There are few reasons to it:

- Most of the product ideas which go to product development stage never reach the market due to non-availability of money, technology, manpower or due to change in demand.

- Many products that do reach the market are not successful mainly due to inferior quality, high product cost, poor functionality, poor marketing skills or change in demand.

Successful products tend to have a shorter life due to change in demand, stiff competition or rapid technological changes. Thus the organisation finds itself on a head on challenge, to develop new product for its survival, yet the odds weigh heavily against their success. So management might be careful in identifying potential product ideas. There are several indicators that can be considered to identify the good product ideas. Product with a gap between demand and supply can be considered as a potential product idea. If some of the idle resources of the plant can be used to manufacture a product, it can be considered a potential product idea. If a product can reduce company's dependence on a select customer base, it can be selected as a potential product idea. Sometime good product ideas may come from our environment (friends, co-workers, etc.). Before selection and conversion of a product idea into reality, management should carry out product analysis to consider various factors in the domain of production and industrial engineering.

Shown in Fig. 2 is a design methodology skewed by the business entities to suit their strategic
directions. The flowchart describes the design process followed in an organisation that manufactures eco-friendly handbags, which do face the challenges thrown upon by the dynamic market demand set by the ever-changing fashion trends. Fashion industries are quite sensitive to the mood of the consumers and their growing knowledge about the world trends and the eco concerns. The amalgamation of the style element, business strategies with the green revolution has forced industries to customize their own applied design methodology as illustrated in Fig. 2.

**Design methodology is a broad area that focuses on:**

- **Divergence**—Exploring possibilities and constraints of inherited situations by applying critical thinking through qualitative and quantitative research methods to create new understanding (problem space) toward better design solutions.
- **Transformation**—Redefining specifications of design solutions which can lead to better guidelines for traditional and contemporary design activities (architecture, graphic, industrial, information, interaction, etc.) and/or multidisciplinary response.
- **Convergence**—Prototyping possible scenarios for better design solutions that incrementally or significantly improve the originally inherited situation.
- **Sustainability**—Managing the process of exploring, redefining and prototyping of design solutions continually over time.
- **Articulation**—the visual relationship between the parts and the whole.

The goal of design methods is to gain key insights or unique essential truths resulting in more holistic solutions in order to achieve better experiences for users with products, services, environments and systems they rely upon. Insight, in this case, is clear and deep investigation of a situation through design methods, thereby grasping the inner nature of things intuitively. Design for manufacturing is concerned with optimizing the manufacturing for cost, quality and productivity. DFM guidelines explain the effect the design has on manufacturing. They are intended to be used by designers during the design phase in conjunction with product functional and aesthetic specifications and, of course, other design for Xs relevant to the product. If correctly followed, they should result in a product that is inherently easier to manufacture.

**Some sample guidelines are presented below:**

- **Aim for simplicity** - minimise part numbers, part variety, and assembly surfaces, simplify assembly sequences, component handling and insertion, for faster and more reliable assembly.
- **Standardise on material usage, components,** and aim for as many off-the-shelf components as possible to allow improved inventory management, reduced tooling, and the benefits of mass production even at low volumes.
- **Reduce the tolerance on non-critical components** and thus reduce operations, and processing times.
- **Choose materials to suit function and production process.**
- **Avoid choosing materials purely for functional characteristics;** material choice must also favour the production process to ensure product reliability.
- **Minimise handling, excessive finishing and inspection to reduce costs and leadtime.**
- **Design in features and functions to overcome process limitations, such as features to aid mechanical feeding.**
Design for environment in addition to estimating cost and other traditional manufacturing performance measures, manufacturing firms are interested in evaluating and reducing the environmental impact of their products. Firms want to reduce the energy that the manufacturing processes consume and the hazardous materials that are produced. Firms are also concerned about pollution prevention and environmental management standards (ISO 14000), customer expectations for products that use less energy and require less maintenance, and regulatory efforts, especially in Europe, to improve the use of recycled materials and the recyclability of products. To date, most efforts have focused on developing design for environment (DFE) and Life Cycle Assessment (LCA) tools and software for specific products and sectors for all stages of design.

During conceptual design, material check lists or justification schemes for high impact materials and matrix assessments that consider multiple impacts for each life cycle stage are common DFE tools. As materials and processes are selected during product embodiment and detailed design, software such as IDEMAT for materials selection, CAD-based product disassembly tools such as Boothroyd and Dewhurst’s DFE tool, and Life Cycle Assessment (LCA) software are used to analyze the environmental impact of product designs. In fact, the current trend is to develop tools and software for specific products and sectors for all stages of design.

Because of the need to balance environmental concerns with other DFX requirements, DFE’s life cycle view has made explicit linkages to supply chain management, pollution prevention and environmental management standards (ISO14000), and customer expectations for products that use less energy and require less maintenance, and regulatory efforts, especially in Europe, to improve the use of recycled materials and the recyclability of products. As such, many companies have integrated related DFE efforts into their business models. Examples include supplier screening at AT&T, Supplier Training at General Motors, supplier ISO14000 Registration at Ford, 3M’s Pollution Prevention Pays Program, and Xerox’s Asset Recycle Management Program.

Interestingly, earlier investigations in the development and use of DFM and DFE design requirements in product design are found that most of the DFM requirements assessed also apply to DFE and vice versa. The goal of reducing cost through DFM, reducing the time to manufacture a product yields not only cost savings but also a reduction in energy use. Similarly, improvements in material and energy efficiency reduce raw material and energy costs as well as materials and waste management costs.

Green manufacturing is the elimination of waste through the production process, wherein the organizations take the responsibility for their actions. End-of-life management used more often then end-of-pipe control. Green manufacturing promotes innovative design. Processes such as JIT and zero emission should be adapted in the organizational strategies. Green manufacturing saves cost but more importantly it saves valuable resources for the future offspring.

Design for Human Energy (DHE) is a proposed product design methodology considering human energy based manufacturing techniques. It an initial step in the product development process. It proposes ZERO artificial energy utilization in the entire process of product development from scratch. DHE covers some techniques to accomplish sustainable manufacturable product. DHE is quite important initiative to provide a very high value to the product which very humble and divine. DHE also strongly influences the material selection process as well to use eco materials which are specifically processed by human energy thereby evolving with a comprehensive sustainable product development. Adoption of DHE also has spin-off benefits like optimum utilization of resources and creation of more opportunities to human hands and preserve and hone traditional knowledge and skills without loosing the core objective of save nature. Manufacturing process inputs to be considered before designing as against the conventional method of choosing the manufacturing process after designing.

DHE guidelines:
- Break down complex parts in to simpler components
- Create more database of Green material
- Eliminate redundant parts & process
- Use natural colors / tanning
- Use masking to add aesthetic value

DHE model is built up the traditional practices followed in India, most of the artisans are inherent designers and largely work individually through the perception is that they are collective. Every artisan
has identified a niche skill which is quite unique to them. Largely these skills can be categorized as raw material specialist fig 3 the choice of raw materials and the sense of understanding the medium by sensibilities like smell, feel, color, and texture is inherent and refined over generations. These business entities are quite independent at micro level and the raw material is traded within the community. These artisans understand the application and the behavior of raw materials during the product conversion phase. The actual manufacturing groups are mostly the women artisans who do develop the products along with the family responsibilities. Most of the raw materials are available at their door step with the required pre work of the raw material form. These available materials are converted into meaningful products are often functional and artistic applications. Many of a time the inspiration is largely drawn from the lifestyles, architectures and the cultural references. The artisans are most work from home in nature and often sell the outcome to the third category that is quite aggressive in nature. They look quite innocent and polished who would have some exposure to the urban scenarios. These artisans are quite sensitive and are aware of the market demands and display their collection to the potential customers at the right platform. Back home they also provide insights to the designers and producers with actual trends they spot. At a macro level when we connect these entities with a common thread of design process, it evident of the design methodology application at the grass root level Fig. 3. The process is well synchronized and are adapting to the modern technologies and policies. They individual businesses are now getting organized into self-help groups and building upon their prevailing strengths.

**DHE - Sisal fiber workshop scenario**

The project involved in the skill mapping of the artisans and organizing them in to three functional domains. Each of these functional group focuses on a specialised task at which they are extremely sensitive and good at. The best practices among the individual members are studied by observation and used as a bench mark for the fellow group members thereby enhancing the productivity capabilities of the groups.

The three basic functional domains identified are the raw material identification and processing group, who specialises in terms of visual identification and extraction of fibres and supply the clean good quality fibers for further product development process. The entire family would be dedicated for this process and their task is only to supply fibre.

The second functional group is the most creative group and uses different techniques to develop new products and applications. Largely this group consists of women who develop the product along with their house hold work of feeding and managing the family. The group buys the raw material sisal fiber from their own counter parts, which are specialist fiber producer and suppliers who are also positioned as a separate strategic business entities.

The third group is largely aggressive and good with communication aspect, which are very apt for marketing the products developed by the artisan group. The marketing SHG visits various fairs retailers and regular clients to supply products. The group also constantly scans for the new marketing opportunities across the globe. The group not only involves in the marketing of the products developed but also quite sensitive to get the focus group reviews and critics. They directly feed from the clients perceptions and always add value to the system by blending the new trend are a perceived / observed in opportunity and expectations of the market. A perfect business model is worked out among the SHG so as to maintain the financial independency and responsibility. The products designed and developed are purchased by the marketing group. Sometimes the products are developed based on the requirements of the marketing group.

**Design for Human Energy (DHE) methodology development**

Indian artisans have always inbuilt conscious eco ethos. People have great respect and are an integral part of their culture to be compassionate with nature and its creations. Since ages, all most all the religions
have well synchronised respect for nature by giving them the divine status. There are many cases that could be illustrated to show that traditional beliefs of Indian societies have got a deeper understanding of the ecological system and have been completely integrated with nature to evolve sustainable lifestyle.

The historic evidences show us the direct relevance of the sustainable ethics of people in India through the well-known pancha tatvas, viz. Prithvi, Agni, Jala, Vayu, and Akasha. Tradition and culture in India had the highest order of respect for these five elements, earth, fire, water, air and sky to further quantify environmental ethics prevalent in India, which leads toward sustainability in every aspect.

Traditional methods of weather forecasting, traditional methods of health care, traditional methods of science and technologies show us some the highest order of techniques the artisans had, India’s indigenous technologies were very sophisticated they included the design and planning of water supply, cattle traffic flow planning, natural air circulation systems, complex stone work, hydraulic engineering, metallurgy and construction engineering.

To be ecologically sustainable, traditional knowledge needs the crucial interface with design to reposition itself and enter the global market, and in the absence of this facility, time honored traditional skills of India are dwindling or are lost.

So much has changed with the formal advent of globalization since the last decade of the twentieth century. Inadvertently or otherwise, an increasing number of sectors have begun to embrace design as a value differentiator - appreciating the value of being at par with the best in the world, a homogenized reality that often imitates established references in style, aesthetics and function as an alternative to the imported labels or products that were desperately sought after until a few years back. Yet, unlike the earlier Design for Development, the emphasis today favours Design for Business. Economics drives development, global investments and policies. And designers, whatever they formally espouse, secretly compare notes on financial successes and media coverage. But in real terms we still need to ask whether we have found our Indian heroes.

Design and crafts interaction has been realized through many platforms, notably art, design or architecture education and practice sustained through cultural anthropologists, sociologists, historians, art curators and those immersed in tradition. Though the approaches varied, but till recently most fell within the broad realm of aesthetic inquiry. The shift to a clearer development focus has unfolded the complexities that need to be addressed as a more holistic approach demands a reality check of strategies and initiatives to ensure effectiveness at the grass root level

**Design opportunity:** The scope of designing and creating a better and more functional more sustainable product. Design opportunity can relate to creating a new product or improving an existing product.

**Understanding the need:** Understand first the needs of the consumer. This step involves understanding how they arise and the context in which they arise. The context takes on significant meaning as seen in later steps since consumers do not always state their needs. Several needs are unstated / obvious depending on the context of use by the consumer and a product that addresses a stated need but ignores an unstated need can lead to dissatisfaction. Understanding of the products and services currently available to the consumer and how it benefits them, and the benefits that it is not providing them, which leads to a need that the product can provide and the consumer can avail of a requirement which has not been looked into before and can now be implemented to make the product/service more functional (Fig. 4).

![Fig. 4—Design for human energy-methodology](image-url)
Analyze: This step involves mapping the needs to benefits. Consumers mostly do not think in terms of benefits and therefore the designer needs to use her understanding of the needs and the context in which those needs arise, to understand the benefits the consumer seeks. The designer then needs to map the benefits to attributes/features that can be incorporated in the product so as to provide those benefits. This step may provide greater insights into the consumer needs and the context of use and therefore may require the designer to go back to understanding of the needs (Fig. 4).

Various concept generations: Once all the needs (both stated and unstated) have been arrived at and mapped to the benefits sought and those further mapped to product features, the designer then needs to generate various designs and methods in which the product can solve the problem. This would involve vague illustrations of product along with sometimes a theme etc, taking into consideration all aspects of the consumer and how is would affect him/her. These are hypothetical ideas which are further refined in the next steps. Proposing various concepts, which represent the product/service as a solution to the need/s that have been identified. proposing various designs and methods in which the product can solve the problem or bring ease in using the service, this would involve vague illustrations of product along with sometimes a theme etc, taking into consideration all aspects of the consumer and how is would affect him/her. They are hypothetical ideas which are further refined (Fig. 4).

Human energy based manufacturing skill mapping: An overall idea of how the product can be manufactured with combined human energy, which would include the time that will take in production and manufacturing, how long each part will take to be produced, how much human energy is required. This would take place without the use of any electrical and mechanical energy. Only human effort would be involved as it is a sustainable design (Fig. 4).

Blending of concept with Human energy based process: Application of the concepts to the available human energy base, assessing which concepts are feasible and can be made easily with human effort.

Finalize promising concepts: See which concepts work the best and finalizing on the concepts within the opportunity parameters.

Build mockups: Build small mockups which would represent the product which would then be manufactured the mockups don’t have to be scaled to real life. They are just examples of how the product would function in the given environment.

Focus group review: The mockups are then used in a focus group review. A focus group review involves an in-depth discussion with a group of prospective users to see and gauge their views on the product and design and get feedback. Through a focus group the designer tries to go beyond simply discussing product features and tries to confirm the validity of earlier assumptions (including unstated needs/benefits) and whether or not the proposed features provide the required benefits. Based on the results of the focus group, the designer may then revise the list of promising concepts and build fresh mockups.

Design detailing: A real life representation through illustrations stating the exact measurements of each of the parts and all information essential in the production of the product, understanding the functioning of all the parts and how they can be put together so the product functions as a whole. All essential detailing required.

Sample prototype: A real life working sample of the product which will function properly. It will give the customer the look and feel of how the original product will function. This sample will be essential in finding any faults that may have occurred during the design process and can be corrected at this stage before it is given for mass production.

Design review: Conclusion of how well, based on the functioning of the prototype, the design has solved the problem first identified. A review of how well the design is, is it worth it, does it meet the requirements of the consumer, would it function properly?

Human energy based production: Finally putting the product out for mass production. No electrical or mechanical energy is used to manufacture these products. Human energy is the prime factor for the production.

Presentation and product environment design: What would be the relationship of the product design and the environment for which it has been designed.

Product launch: Product is finally launched into the market.

Design for Human Energy (DHE) methodology validation

The design methodology proposed was validated and applied on the field for design and development
of products. The design brief was clearly articulated after understanding the intricacies of the craft beforehand. The brief was developed and refined after looking into various aspects like existing products, trend and forecast analysis, competitive prices, client preferences (national and international), potential market avenues and other relevant direct influencers.

The well-articulated defined brief was applied with the sisal fibre craft artisans from Kuderu tribal rehabilitee settlement of Chamarajanagar district in Karnataka. The artisans are evacuated group from the national reserve forest to protect tigers and other forest assets. There was a strong urge from various governmental agencies to support these groups with capabilities for their sustained livelihood.

The spin off benefit of the field workshop conducted also gave them to identify the opportunity of the raw material, sisal which is around them and leverage its fullest potential through this design intervention. The workshop started off with lots of hope, and various stake holders including the media were the evaluators and contributors. The workshop was financially supported by NABARD which is directly under the Reserve Bank of India (Fig. 5).

The artisans were then given an opportunity to explore the urban markets and meet their potential customers, whom they need to cater by their product offerings. The artisans were trained to develop the design brief based on their observation and interaction with the urban customer (Fig. 6).

Utmost care was taken during this phase of training so that the traditional essence of their cultural values is not diluted. Most of the forms and motifs they developed had a direct relevance to their culture and lifestyle.

Sustainable product cost analysis

It is viewed that the environment as a mainstream business issue and highlight the improving resource productivity as an overriding priority for future competitiveness of the country’s economy. Improving resource productivity – how to produce more goods and services with fewer inputs of materials and utilities, and with less pollution and waste – will increase business efficiency, and hence profits. Many artisans do not fully understand the implications of environmental factors on their business – largely because of the cost perspective. Adopting the methodology and techniques gives designers the opportunity to take a more strategic view of how current and forthcoming environmental factors will affect the business’s short term profits and longer term competitive advantage. From the consumers point of view the real question is not how expensive sustainable products are, but how our purchasing habits affect the global population and environment. The prices of sustainably produced products and services reflect the true cost of the purchases.
Conclusion

It’s relevant to the context to think and act sustainably, here sustainability does just end to use the sustainable materials and restrict ourselves to the waste eliminating manufacturing process. It’s about thinking and adapting our whole thought process in a sustainable fashion. It’s an attitude which is proposed to be built in to the designers mind. Sustainable practices also mean of effective utilization of available Human resources and the skill sets. The adaptation of the product design practices with the perspective of Design for human energy has been validated and may not change the entire product, but an attempt is at least to make a small change that impacts one percent of the new products that are incubating. The proposed methodology has also been applied into some product category and has a tremendous amount of satisfaction and pleasure in changing a small bit which could be a radical change agent of tomorrow. This method engages in how to think like design or observe designers’ thinking. Design method is a key to solve the problem and it is a way to build up body of design knowledge. Sustainable design and consumption can only be achieved all the actors across the life cycle take their own responsibility. The ultimate goal is therefore taking into account environment in every decision making process by the designers. The proposed method shall contribute to the incorporation of environment in all the product design decisions.

Significant tangible outcome

The process of validating design methodology in the field level was completely monitored and guided, in the initial stages to solve the teething problems and the apprehensions the artisans would have. The process was toe-held for about a year in a phased manner. The design workshop has been completely successful in terms designing sustainable products as per the demands of the clients. Empower the artisans with Design capability and develop sustainable employment through DHE with alternate source of income for the below poverty line families.

The products designed are marketed through various channels under the brand “Aarambh” which is owned by the community of SHGs (Fig. 7).

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